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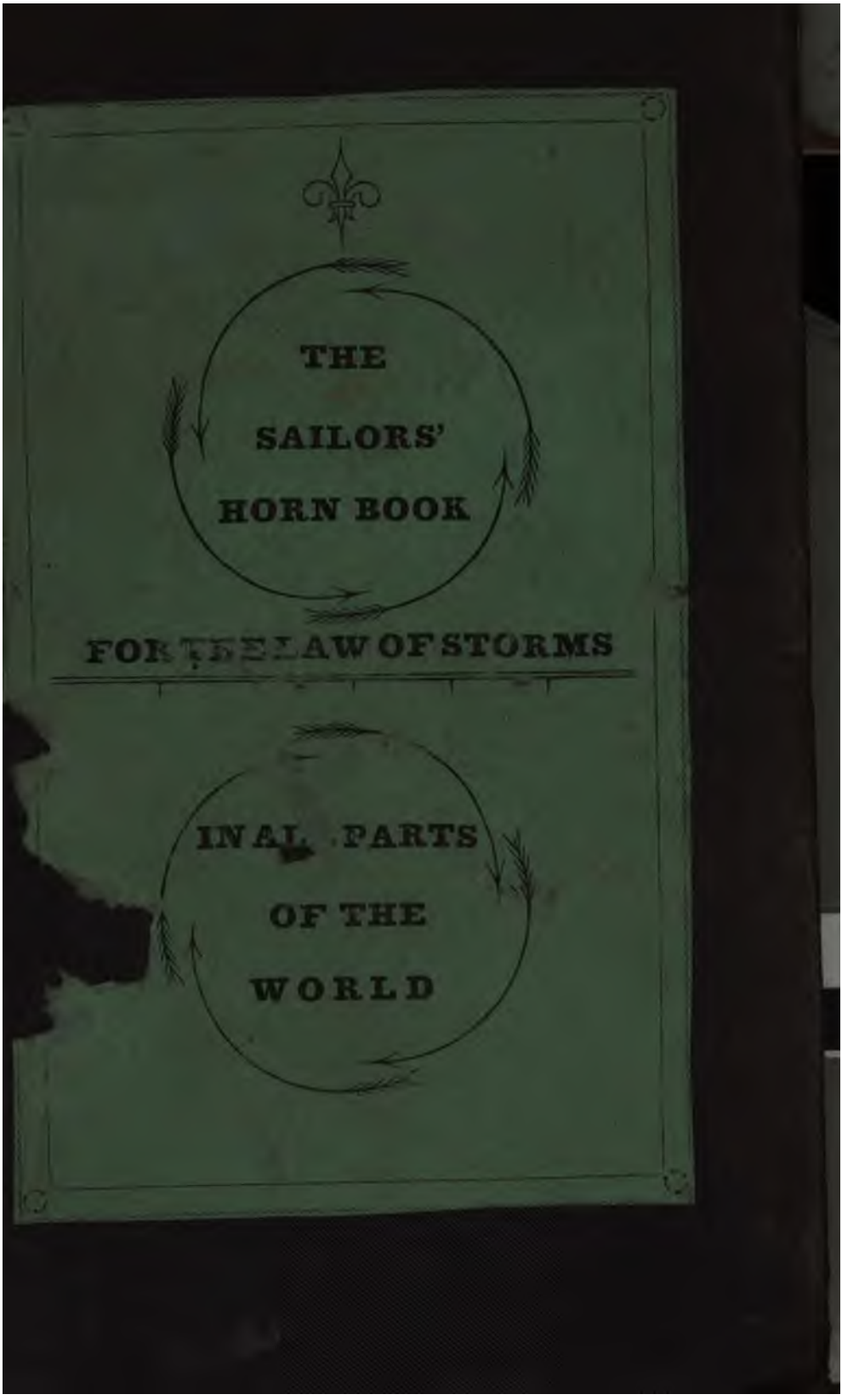
THE
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IN ALL PARTS
OF THE
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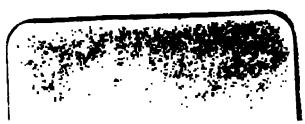

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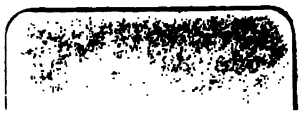

THE SAILOR'S HORN-BOOK

FOR THE

LAW OF STORMS:

BEING

A PRACTICAL EXPOSITION OF THE THEORY OF THE LAW OF STORMS,

AND

ITS USES TO MARINERS OF ALL CLASSES

IN ALL PARTS OF THE WORLD,

SHEWN BY

Transparent Storm Cards and Useful Lessons.

BY HENRY PIDDINGTON,

PRESIDENT OF MARINE COURTS OF ENQUIRY, CALCUTTA.

"Wherein, if any man, considering the parts thereof which I have enumerated, do judge that our labour is to collect into an art or science that which hath been pretermitted by others as matters of common sense and experience, he judgeth well."

BACON,
De Aug. Scient.

Perhaps this storm is sent with healing breath
From neighbouring shores to scourge disease and death?
'Tis ours on thine unerring LAWS to trust,
With thee, great Lord! 'whatever is, is just.'

FALCONER—*Shipwreck*,
Canto II. 884.

LONDON:

1848.

PUBLISHED BY SMITH, ELDER AND CO., 65, CORNHILL; AND WILEY AND PUTNAM, NEW YORK; AND SOLD BY ALL NAVAL AND SCIENTIFIC BOOKSELLERS IN ENGLAND AND AMERICA.

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THE SAILOR'S HORN-BOOK.

DESIGN OF THE WORK.

WHAT I propose in this work is, to explain to the seaman, in such language that every man who can work a day's-work can understand it, the Theory and the Practical Use of the **Law of Storms** for all parts of the world; for this science has now become so essential a part of nautical knowledge that every seaman who conscientiously desires to fulfil his duties, from the Admiral of a great fleet down to the humble Master of a West India or Mediterranean trader, must wish to know at all events what this new science is: of which he hears it said, that it teaches how to *avoid* Storms—teaches how best to *manage in Storms* when they cannot be avoided—and teaches how to *profit by Storms!* A man who thoroughly understands all this, must have as great professional advantages over one who does not, as our fleets and ships of the present day, when scurvy is almost unknown, have, in that respect, over those of the days of **Anson**, when whole crews were swept off by it.

To enable the plainest ship master, then, clearly to comprehend this science in all its bearings and uses, and as far as our present know-

ledge extends, is my first object; and on this account I have endeavoured to make the work as clear and as brief as possible; though as still intended for all classes of mariners, the scientific as well as the unlearned, and intended also while it explains, to suggest; to ask for; and to urge further enquiry, I have not passed over the more scientific part, while striving to give to the mariner of all classes a cheap book of the results of all the researches up to the present time; together with the principles of the science so clearly indicated, that he might be fully satisfied as to them, and, if he pleased, look farther to investigate their origin and effects, and furnish those who are prosecuting the research with further materials.

Every one who has mixed much with sailors, and every educated man who reflects on his early life amongst them, must have remarked, from the Naval officer to the coasting skipper, not only the many instances in which misdirected, imperfect, or limited education in youth has dulled the faculties for improvement; and thus all times and opportunities in after life have been neglected; but with too many also, alas! even where in youth or manhood inclined to any self-improvement, the truth of Falconer's beautiful lines, which though written of classical literature are not less true of scientific pursuits and of the professional improvement dependent on them—

> "..... for blasted in the barren shade
> Here, all too soon, the buds of science fade!
> Sad Ocean's genius in untimely hour
> Withers the bloom of every springing flower:
> Here fancy droops, while sullen clouds and storm
> The generous climate of the soul deform."

And this I trust will be my apology, if any be needed, for preferring the familiar terms of common sailor-language where I could use them as I think with better effect, to more scientific forms of expression. I have thought, in a word, that the work might lose much of (I trust,

I may say its national) utility, if written only for the state-rooms of science; and thus I have preferred to seat it at her cabin-table—claiming only in this respect, from those who might wish it otherwise, a moment's reflection on how large a class of our brother-sailors there are, and always must be, who though worthy and most valuable men, have wanted the inestimable advantages of a good education; and might be repelled from the study by the sight of "hard words" and the sound of scientific phrases, however familiar such may be to our ears.

In the style of printing, and by the frequent use of italics, as well as by a copious Index and detailed Table of Contents, I have endeavoured, as far as possible, to assist the reader to a quick and clear comprehension of what is said; for I know that many forget that "a hurricane at sea is like a battle in a campaign; an important, but unfrequent occurrence, for which it is wise to be well prepared;"* and, rarely looking at works like the present till they want assistance from them, are thus very liable to mistakes in a moment of anxiety. If such, however, will but give it one fair perusal at leisure, they may perhaps, recollecting with quaint old **Thomas Fuller**, that "the winds are not only wild in a storm, but even stark mad in a hurricane,"† find that a little study in fine weather may save a world of labour and mischief in bad.

I should perhaps apologise for the apparent egotism of quoting so often my own Storm Memoirs, but in truth they form, as will be seen by the list of them in the next page and the note of works on the

---

* Foreign Quarterly Review for April 1839: supposed to be written by Captain **Basil Hall.**

† **Fuller's "Holy State."** "*The Good Sea Captain.*"

science at p. 282, a considerable portion, as to bulk at least, of the evidence, new and corroborative, upon which our science rests; and often furnish details and exact data which I could not elsewhere obtain.

Writing in Calcutta, I have been unable to consult many books of voyages, and especially the works of the older and foreign navigators that I could have desired to examine or refer to, and my labours are continued under difficulties and even against positive discouragements which would be hardly credible if told; but the reader will nevertheless, I trust, find that he has a tolerably complete work for all really useful purposes, and that he has in many respects much more than was originally announced in the Prospectus.

H. P.

CALCUTTA, 1*st January*, 1848.

Errata.

iii. Design of the work, line 5 from top; "there are" *read* "there is."

Page 48, line 5; for "341" *read* "346."

48, line 8; for "**Williams**" *read* "**Sullivan.**"

41, line 22; for "1889" *read* "1839"

55, note; for "Alleppo" *read* "Aleppo."

73, line 4 from bottom; for "Stormcard" *read* "Storm Card."

4, line 9 from top; add § 10.

187, line 7 from top; for "low sail" *read* "low square sail."

93, note; for "sort of" *read* "a sort of."

273, line 2 from top; *dele* "them."

291, line 8 from bottom; for "he" *read* "the."

151, line 20 from top; for Track "G" *read* Track "*g*."

Directions to the Binder.

Table of Contents to follow the title.

Place the Barometrical Chart fronting page 193, and fold it along the double line, below the word Centre at top.

A table of references to be placed fronting Charts II., III. and IV.

The Charts to be placed at the end of the book.

List of publications to face page 1.

Publications by the Author on the Law of Storms in the Indian and China Seas.

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pp.

1.—*First* Memoir. "Hurricane in the Bay of Bengal, June 1839." J. A. S. Vol. VIII. 45

2.—*Second* Memoir. "Coringa Hurricane, of November 1839, with other Storms." J. A. S. Vol. IX. 45

3.—*Third* Memoir. "Cuttack Hurricane, of April and May 1840." J. A. S. Vol. IX. 46

4.—*Fourth* Memoir. "The *Golconda's* Tyfoon in the China Seas, September 1840." J. A. S. Vol. IX. 11

5.—*Fifth* Memoir. "Madras Hurricane, of May 1841, and Whirlwind of the *Paquebot des Mers du Sud.*" J. A. S. Vol. XI. 19

6.—*Sixth* Memoir. "Storms of the China Seas, from 1780 to 1841." J. A. S. Vol. XI. 100

7.—Two Editions of "Notes on the Law of Storms in the Indian and Chinese Seas, presented to, and printed by, the Government of India, for the use of the Expedition to China." 42

8.—Notes on the Law of Storms in the Indian and China Seas, arranged for, and presented to, Rushton's Directory. 8

9.—*Seventh* Memoir. "Calcutta Hurricane, 2nd—3rd June 1842." J. A. S. Vol. XI. 24

10.—*Eighth* Memoir. "Madras and Arabian Sea Hurricanes, 22nd October to 1st November 1842." J. A. S. Vol. XII. 61

11.—*Ninth* Memoir. "Pooree, Cuttack and Gya Storms, of October 1842." J. A. S. Vol. XII. 42

12.—*Tenth* Memoir. "Madras and Masulipatam Storm, 21st to 23rd May 1843." J. A. S. Vol. XIII. 45

13.—On an improved Simpiesometer, "The Tropical Tempest Simpiesometer." J. A. S. Vol. XII. 2

14.—*Eleventh* Memoir. "Storms in the Bay of Bengal and Southern Indian Ocean, 26th November to 2nd December 1842." J. A. S. Vol. XIV. 66

15.—*Twelfth* Memoir. "The *Briton* and *Runnymede's* Hurricane in the Andaman Sea." J. A. S. Vol. XIV. 23

16.—*Thirteenth* Memoir. "The *Charles Heddle's* Storm off the Mauritius." J. A. S. Vol. XIV. 33

17.—*Fourteenth* Memoir. "Bay of Bengal, Ceylon and Arabian Sea Storms" of 29th November to 5th December 1845, J. A. S. Vol. XIV. ... 40

THE SAILOR'S HORN-BOOK.

PART I.

BRIEF HISTORY OF THE SCIENCE OF THE LAW OF STORMS. —2. EXPLANATION OF THESE WORDS AND OF A FEW OTHER TERMS.—3. VARIOUS THEORIES NOTICED AS TO THE MOTIONS, AND BRIEFLY AS TO THE CAUSES, OF STORMS.

1. It is perhaps more than a century ago since the first accounts were published of ships which had scudded in a hurricane for a day or more and yet found themselves "nearly in the same place as when the gale began," and the oldest seaman has heard instances of this strange and then inexplicable circumstance, as well as of ships, which in lying to had the wind either veering all round the compass, or shifting suddenly, with or without a calm interval, to an opposite point of the compass, and blowing harder than before, or of ships which, though but a short distance from each other, had furious hurricanes, dismasting and bringing them near to foundering from opposite points of the compass, and yet veering differently with both; but no author before the commencement of the last century appears to have thought of accounting for this, and most perhaps believed that it never could be accounted for.

2. The earliest published account we have of these Storms being distinctly considered as whirlwinds is by a Captain **Langford,** in the "Philosophical Transactions" for 1698, in a paper on the West Indian hurricanes, which he calls "whirlwinds." He describes the veering of the wind, advises putting to sea with the Northerly winds to get sea-room, and come back with the S. Easterly ones "when *his* fury is over," describes their progression! and gives some limits for them. He has of course also a theory to account for their origin.

There are indeed frequent passages to be met with in the older navigators and travellers which directly or indirectly speak of the

violent storms of the tropics as "whirlwinds." It is remarkable that **Don Juan de Ulloa** (in 1743) fully describes rotary storms and shifts of wind on the Pacific Coast of South America, as will be seen in an extract subsequently given, but does not seem (in the English translation, which may be an abridgment) to have heard of, or to consider them as whirlwinds.

3. In a work published in 1801,* Colonel **Capper** speaking of the Madras and Coromandel Coast hurricanes, says,—p. 61.

"All these circumstances properly considered clearly manifest the nature of these winds, or rather positively prove them to be whirlwinds whose diameter cannot be more than 120 miles, and the vortex seems generally near Madras or Pulicat."

And again, after describing some on the Malabar Coast and in the Southern Indian Ocean, he says—p. 64,

"Thus then it appears that these tempests or hurricanes are tornadoes or local whirlwinds, and are felt with at least equal violence on the sea-coast and at some little distance out at sea."

4. In **Horsburgh's** Directory, first published in the early part of the present century, he alludes to storms, particularly those of the China Sea, as being *rotatory*, i. e. great whirlwinds.

5. A French author, **Romme**, in a work of much research,† published in 1806, describes the Tyfoon of the China Sea about the Gulf of Tonkin as a "*tourbillon*" (whirlwind); and again speaking of the gales of the Mosambique Channel, he distinctly says, that during the N. E. monsoon the heaviest tempests are felt there, and that "*then the winds change to whirlwinds* (tourbillons) with a high sea, cloudy sky and heavy rain, Vol. II. pp. 106, 132." The same author describes those of the Gulf of Mexico, p. 45, as hurricanes and whirlwinds. He also describes very fully the veering of the winds in the hurricanes of the Bay of Bengal, pp. 148 to 150, but does not, when speaking of these last, call them distinctly whirlwinds.

6. Hence we see that, up to the first ten years of the present century, all that appears known and published of tropical storms and hurricanes was, that they were often great whirlwinds. **Franklin**

* Observations on Winds and Monsoons.

† Tableaux des Vents des Marées et des Courans.

had indeed shewn in 1760 that the NE. storms of the American Coast came from the SW., but he did not prosecute the inquiry farther.

7. Fortunately for science, however, Mr. William **Redfield**, of New York, had his attention drawn to the subject in the course of his professional pursuits as a Naval Architect, and in 1831 published in the "American Journal of Science" a valuable paper, the first of a numerous series which have since followed, in which he demonstrated not only that the storms of the American Coast were whirlwinds, but moreover that they were *progressive* whirlwinds moving forwards on curved tracks at a considerable rate, and were traceable from the West Indies and along the Coast of the United States till they curved off to the Eastward between the Bermudas and the Banks of Newfoundland. He also gave many excellent practical rules for the management of ships, so as to avoid, or at least to diminish, the chances of damages from rotatory storms, and valuable remarks on the Barometer as a guide.

8. In an able article on the Law of Storms in the "North American Review," for April 1844, is the following, which is not only part of the history of our Science, but moreover a well merited tribute to the labours of the gentlemen named in it—and I do not mean here to speak with less respect of those whose views have, I think, been proved erroneous. No one can have undertaken independent researches in any branch of the physical sciences without soon feeling that mankind owe much more than is usually supposed to those who have missed their road; they are the soldiers who have fallen, the successful are the victors who survive to reap the honours of the combat.

"About the time that the American philosopher **Redfield** was employed in his earlier labors of observing and collecting the observations of others, a similar inquiry was in progress in Germany. On Christmas eve, 1821, after a long continuance of stormy weather, the barometer sank so low in Europe, that the attention of meteorologists was strongly drawn to the circumstance. M. **Brande**, having obtained the registers kept at this time in various places, came to the conclusion, that, during this storm, the winds blew from all points of the compass towards a central space, where the barometer was, for the moment, at its lowest stand. This conclusion was disputed by Professor **Dove**, of Berlin, who subjected the observations in the possession of **Brande**, as well as others, to a new examination, and made it appear, that an explanation of all the phenomena was afforded by the assumption of one or more great rotary

currents, or whirlwinds, advancing from the Southwest to the Northeast.* Before this discussion was known in the United States, Mr. **Redfield,** by an independent course of investigation, had arrived at the result we have already announced, and his opinion is fortified by facts and cases so numerous and well authenticated, as fully to justify the distinction which Sir **David Brewster** has accorded to him in the following language 'The theory of rotary storms was first suggested by Colonel **Capper,** but we must claim for Mr. **Redfield** the greater honor of having fully investigated the subject, and apparently established the theory upon an impregnable basis.' "†

9. Mr. **Redfield** was followed in 1838 by Lieut.-Col. **Reid** of the Royal Engineers, who published the valuable and well known work usually called "**Reid** on the Law of Storms," in which he not only fully confirmed Mr. **Redfield's** views, but added most extensively to the proofs of them, by investigations of the West Indian Hurricanes, and those of the Southern Indian Ocean, and moreover by proving farther what **Redfield** had already announced theoretically, that in the Southern Hemisphere the Storms revolve in a contrary direction to those in the Northern one.

The great step of bringing the science to full practical use was also made by Colonel **Reid,** who showed that safe rules for scudding or lying to in a hurricane might be deduced from the theory, and that, farther, when obliged to lie to, ships should, to avoid being taken aback by the veering of the wind heading them off, chose a particular tack to lie to on, according to the side of the path of the Storm on which they were; and lastly that ships might often, by means of this knowledge, *profit* by storms by sailing *round* instead of *through* them; and the theory like so many other sciences then became from a speculative view, or *theory* of which the uses had been only remotely and dimly foreseen and hoped for, a practical *Law.*—THE LAW OF STORMS; of the first use to the mariner, and of the highest importance to every naval and commercial nation.

11. Thus far may be called the history of the Law of Storms‡ from its early suppositions and proofs to its establishment. I

* London and Edinburgh Journal of Science, Nos. 67, 68.

† Philosophical Magazine, vol. XVIII. 3rd series, p. 515.

‡ I have not alluded to Mr. **Espy's** theory, as not being ours, and as I think being wholly contradicted by facts. It consists of two parts, the causes of hurricanes, and their effects. To this theory I shall allude subsequently.

may add, that Dr. A. **Thom,** of H. M. 86th Regt., has published also, in 1845, a valuable work on the science generally, and more particularly relating to the Storms of the Mauritius and Southern Indian Ocean. A list of my own publications on the subject from 1839 to the present day, relating to the China, Arabian and Andaman Seas, Bay of Bengal and Southern Indian Ocean, amounting, if collected, to a volume of 650 pp. with 30 plates and diagrams, will be seen at the commencement of the present chapter. Amongst our results here are: The ascertaining of the average tracks of storms in various seas: The *division* of storms: The frequent occurrence of *double* storms: The *incurving* of winds in a hurricane, and the proofs of the *storm wave* and *storm currents*, with minor matters, to all of which I shall subsequently refer. It is worth noting, however, before concluding this section, how it seems here and there to have been impressed on the minds of many observant seamen long ago that great storms and hurricanes were great whirlwinds. Mr. **Redfield** quotes a letter of Capt. **Waterman** of the "Illinois," in his memoir of 1831, p. 24, which concludes thus—"I have only to add that from an experience of 20 or 30 years, during which time I have been constantly navigating the Atlantic, my mind is fully made up that heavy winds or hurricanes run in the form of whirlwinds."

12. **Explanation of the words Law of Storms, and of some other terms.** In the foregoing pages I have spoken of the *Law* of Storms as a Theory from which when confirmed as a *Law*, Col. **Reid** has deduced the rules which render it of practical utility.*

* *Theory* and *Law.* The seaman may best understand these two words by his quadrant. As long as people who paid attention to these things *supposed* that light when reflected from a mirror was always so at a certain angle depending somehow on the direction in which the original light fell upon it, this was a theory. When it was *proved* by experiment that the angle of reflection was equal to the angle of incidence this became the *Law* of reflection, and when Hadley applied it to obtain correct altitudes, and to double the angle by the two reflections of the quadrant, he used it for a nautical object of the first importance and of daily practical utility. These are the three great steps of human knowledge and progress. The theory, or supposition that a thing always occurs according to certain rules, the proof or Law that it does and will always so occur, and the application of that Law to the business of common life.

The words **Law of Storms,** then, signify first, that it has now been proved by the examination and careful analysis of perhaps more than a thousand logs and of some hundreds of storms by the authors already referred to, and by many other observers in periodical publications and some whose results have not yet been published, that the wind in hurricanes, and frequently in severe storms in the higher latitudes on both sides of the Equator, has two motions. It turns or blows *round* a focus or *centre* in a more or less circular form* and at the same time has a straight or curved motion forward, so that, like a great whirlwind, it is both turning round and as it were *rolling* forward at the same time.

13. Next it is proved that it turns, when it occurs on the North side of the Equator, from the east, or the right hand, by the north, towards the west, or *contrary* to the hands of a watch, or ; and in the Southern hemisphere that its motion is the other way, or *with* the hands of a watch ; being thus, as expressed by Professor **Dove** of Berlin, S. E. N. W. for the Northern hemisphere, and N. E. S. W. for the Southern hemisphere, if we begin always at the right hand, or east side of the circles.

14. These two principal Laws constitute the rule or **Law of Storms.** And it has, as before said, been abundantly demonstrated to hold good for several parts of the world, but in others though our evidence is very deficient, and sometimes indeed we have none at all, we must *assume* it only to be true; but we do so on very strong grounds; those of the great analogy usually existing in the laws of nature, and the fact that every new investigation affords us new proofs of the truth of our law in both hemispheres.

15. In its application also to Nautical uses the new Science is called the **Law of Storms,** and here it means that it offers a kind of knowledge, which in most cases, will afford the Seaman —FIRST, the best chance of avoiding the most violent and dangerous part of a hurricane, which is always near the centre of it; NEXT, the safest way of managing his vessel, if he is involved in one; and THIRDLY, the means of *profiting* by a storm! by sailing on a

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* Look at the Storm Cards in the pockets of the book.

circular course round it, instead of upon a straight one through it, supposing always in this last case that he has sea-room.

16. STORM.—This term "storm" is not used so much with relation to the *force* of the wind in a storm, as to its *motion.*

A storm or tempest, may mean either a gale or a hurricane; but it always means in our science a storm of wind; and not, as frequently used by landsmen, one of thunder and lightning only.

A GALE means a storm of wind, the direction of which is tolerably steady for a long time; sometimes not only for days, but for weeks, as our common monsoon gales and the winter gales of the Channel and Bay of Biscay.

A HURRICANE means a *turning* storm of wind blowing with great violence, and often shifting more or less suddenly, so as to blow half or entirely round the compass in a few hours. The words *storm* and *hurricane* are both used in this book to indicate a *turning* gale; hurricane when it is of excessive violence.*

There are in tropical latitudes and as far as 50° or 55° N. and S. of the equator two kinds of tempests or storms. The monsoon or trade wind *gales,* in which the barometer remains high and the wind steady, and the hurricanes, or tyfoons, often blowing with irresistible fury, and almost invariably accompanied by a falling barometer.

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* After all, these words Storm, Gale, Hurricane, Tempest, &c. are very liable to be used indiscriminately and confounded, and thus produce some perplexity, and even mislead the plain seaman. Our new science having demonstrated a circular or vortex-like (vorticular,) motion, requires a new word to distinguish winds of all kinds, having greatly curved courses, from those which like the trades and monsoons we may assume to be blowing in straight or nearly straight lines. Copying from Mr. Redfield's first memoir "On facts in Meteorology" most of the following names, I have classed them, not as he has done according to their strength, but according to the nature of their motion noting with an (?) those of which we are as yet doubtful.

CLASS I.

Right lined (straight) winds.

Trade winds.	Etesian winds. (?)
Monsoons.	Harmattan. (?)
Some gales of high latitudes. (?)	Land and Sea breezes.
White squalls, (Coast of Africa.)	North-Westers (of Bengal.)

Perhaps they occur even farther from the Equator, but we have no good evidence beyond the storms of the Channel, and some off the Cape of Good Hope.

* Tornado sometimes (?)	Sumatras (of the Straits of Malacca.)
Flaws and Gusts.	North Westers of India.
Some common squalls.	Helm wind (Cumberland and mountainous Countries.)
Rain-winds (from a fall of rain near the spot, as at cascades, &c.)	Pampero of La Plata.
Scirocco, (?)	

CLASS II.

Circular (or highly curved) winds.

Hurricane Storms. Some gales of high latitudes (?)	African Tornado, (sometimes ?)
	Water spouts.
Whirlwinds—of wind, rain, dust, &c. —called in Spanish, French, Portuguese, &c. *Turbo, Turbonado, Tourbillion, Tourmente.*	Bursting of Spouts water spouts, &c.
	Samiel.
	Simoom.

I am not altogether averse to new names, but I well know how sailors, and indeed many landsmen; dislike them; I suggest, however, that we might perhaps for all this last class, of circular or highly curved winds, adopt the term "**Cyclone**" from the Greek **Κυκλως** (which signifies amongst other things the coil of a snake) as neither affirming the circle to be a true one, though the circuit may be complete, yet expressing sufficiently the *tendency* to circular motion in these meteors. We should by the use of it be able to speak without confounding names which may express either straight or circular winds—such as "gale, storm, hurricane," &c.—with those which are more frequently used (as hurricane) to designate merely their strength. This is what leads to confusion, for we say of, and we the authors ourselves write about, ships and places in the same "storm" having "the *storm*" commencing—"the *gale* increasing"—"the *hurricane* passing over"—and the like; merely because the ships or localities of which we speak had the wind of different degrees of strength, though the whole were experiencing parts of the same circular storm. *Cycloidal* is a known word, but it expresses relation to a defined geometrical curve and one not approaching our usual views, which are those of something *nearly*, though not perfectly, circular. Now if we used a single word and said The "*Cyclone*" commenced, increased, passed over, &c. we shall get rid of all this ambiguity, and use the same word to express the same thing in all cases; and this without any relation

* Mr. Redfield distinctly proves one tornado, the New Brunswick one, to have had a whirling motion, and Colonel Reid adduces a log of H. M. S. Tartar off the Coast of Africa, proving that the tornados are, sometimes at least, rotatory.

17. THE STORM WAVE is a mass of water of greater or less diameter according to the storm, raised above the usual level of the ocean by the diminished atmospheric pressure, and perhaps other causes, and driven bodily along with the storm or before it, and when it reaches bays or river mouths, or other confined situations, causing by its further rise when contracting, dreadful inundations; but upon open coasts rarely so, or not in so great a degree, as it can there spread out quickly and find its level.* The STORM CURRENTS may be briefly described as circular streams on the circumferences of rotatory storms (Cyclones) and of these also we have evidence enough for the mariner at all times to admit, and be on his guard against the *possibility of*, or even the *great probability of*, them.

We have thus in every circular storm (Cyclone) two sets of forces (currents) independent of that of the wind, acting upon a ship; the one carrying her bodily onward on its track and the other drifting her round the periphery of that part of the storm circle (Cyclone), in which she may be.

18. STORM CARDS. The horn plates in the pockets of this book are what is called Col. **Reid's** Hurricane, or Storm, Circles, or Cards.

The use of these is to lay down and move upon any part of a chart; they may be supposed to represent a circular storm (Cyclone)

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to the *strength* of the wind for which we might freely use all the words "breeze," "gale," "storm," "tempest" "hurricane," "tyfoon," &c. as we pleased.* Without then changing the usual terms I shall so far *propose* the new word as to add it in a parenthesis wherever I wish to express a wind blowing in a circuit, whether that be a circle, or an ellipse, or a wind describing a spiral by its progression while turning.

* The deep-sea wave also, (the *flot de fond* of the French writers) no doubt assists the inundation; but as this is not a surface cause, I do not allude to it here.

* I have now before me (October 1846) a newspaper extract giving an account of a meeting of the florists, market gardeners, &c. of the South London district, to consider of means to repair their losses in a severe thunder and hail storm which occurred in the month of July or August of that year. In this article the words "hurricane," "gale," "storm" and "hurricane" are used to speak of the "meteor" as the French would call it. And in another, giving an account of the storm which visited Edinburgh on the 4th March, the tempest is alternately spoken of as a "gale and a hurricane," and Professor Nicol, of the Glasgow Observatory, finally speaks of it as a "storm of translation," or a moving whirlwind "of large radius but of immense power;" the simple word *Cyclone* would express all which Professor Nicol wished to say, and he would then as well as the editor of the newspaper, have had all his words to express the *violence* of the (hail and thunder) storm without, by using the term hurricane for instance, leading their readers to suppose that there was any thing rotatory about the wind if they did not mean to express this.

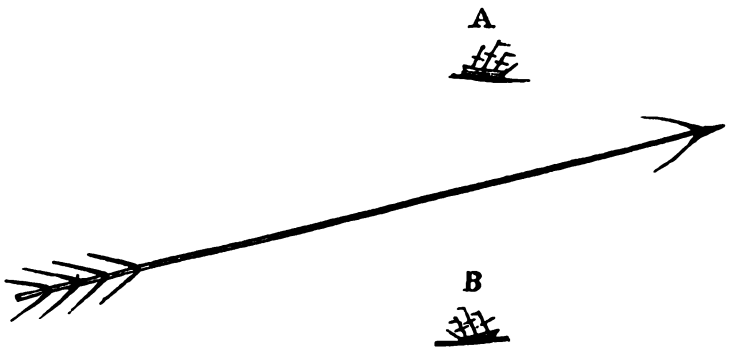
of fifty, or of five hundred miles in diameter, as we please; and one which would fill up the North part of the Bay of Bengal, would shew the wind in the same storm, South on the coast of Arracan; East on the Sand Heads; North on the coast of Orissa; and West across the middle of the Bay; and if we move it over a chart, the changes of the wind for a ship or an island on its track will be seen. If placed with the centre between Barbadoes, St. Vincent's and St. Lucia on a Chart of the West Indies, it will show how the wind may be for these Islands, or for ships in those positions NN. Easterly and NN. Westerly for St. Vincent's and St. Lucia, and SS. Westerly for Barbadoes at the same hour. This is with the card for the Northern Hemisphere. With that for the Southern Hemisphere every thing is the contrary way; and if the Card for that hemisphere is laid between the Mauritius and Bourbon it will be seen then that a S.E. Hurricane (Cyclone) at Bourbon may, if large enough to reach so far, be a N. Westerly one at the Mauritius; and so on all over the world in each hemisphere.

19. The TRACK of a storm is the line or path along which it moves, and we usually speak of the imaginary line or path made by the centre as *the* track, though we might call the whole breadth passed over by the storm its track or road, if we pleased. These tracks are different in different parts of the world and in different latitudes, and together with the ascertaining *certainly* if the usual law of veering prevails every where, are the great objects of the researches now going on; because much of the management of a ship depends upon our knowledge of the track of the storm, as will be subsequently seen.

20. THE CENTRE, OR FOCUS, or calm centre, *or focus*, or lull, is a space of calm, often, but not always, formed about the centre of hurricane-storms, (Cyclones) and which varies like the storms (Cyclones) themselves in its diameter, and according to their rate of motion in its duration while passing over an Island or station, or while a ship may be drifting through it or round it.

21. The TURNING and the VEERING of the wind in a hurricane-storm (Cyclone.) The seaman should be careful not to confound these two words, though so nearly alike in meaning and in the ideas they convey. When we say that in either hemisphere the wind *turns* so and so in a rotatory gale (Cyclone) we mean to express

thereby that the *whole body* of the storm, whatever be its extent, is whirling round (turning) with or against the hands (hours) of a watch; but when we say the wind *veers*, or will *veer*, in a given direction, we mean then to speak always of its changes or shifts, whether gradual or sudden, in different parts of the circle, so that the wind in a hurricane or circular storm (Cyclone) while it really *turns* but one way, according to the hemisphere in which the storm occurs, may, with ships on different sides of its track be *veering* in apparent contradiction with each other, and with the law given. Thus if, as in the figure below, two ships A. and B. in the Northern hemisphere are at 80 miles distance from each other and a storm is travelling towards them from the W. b. S. or WSW. to the ENE. as in the Northern Atlantic Ocean, it will be seen by moving the centre of the horn card along the arrow that the successive changes are,



For A.	*For B.*
SE.b.S.	SSW.
SE.	SW.
ESE.	WSW.
East	West
NE.	WNW.
NNE.	NW.
North	NW.

and it will be seen that one of these is what sailors call "*backing*" round, and this explains what is so often matter of contradiction and confusion, a ship sometimes in one-half of a storm (Cyclone) having the wind '*veering*' and then *backing*—when she gets into the opposite half of the storm circle. In this example we have supposed the ships lying to; if scudding and thus rapidly changing their positions the changes of wind will of course differ. Mr. **Redfield** says, p. 175 of "American Journal of Science and Arts," Second Series No. 2, touching this subject:—

"*The paradox of revolving winds.* It is still possible that some persons may not at all be able to understand, clearly, how the wind in a progressive storm which revolves in one constant direction around its axis, can at the same time be found to veer in opposite directions, on the opposite sides of the axis line as is seen in Tables I and III respectively. But this fact, of which an explanation has already been attempted, may be seen to be a necessary result of the law of rotation, as manifested in all revolving bodies, and failing to understand this law, no one can intelligently pursue the enquiry.

"Let a circular disk of stiff paper be written upon in one or more circular lines, around its centre, either in a concentric or vorticose form; then put this disk in rotation upon its centre, and pass two fingers across it in parallel directions, one on each side of the axis, and it will be found that one finger passes the circular writing in the order in which the words are written, while on the opposite side of the axis the other finger, though moving in the same direction, will pass over the writing in the opposite or reverse order to that in which the words are written. Of course this will equally follow in case the revolving disk be advanced under the fingers, as when the fingers are advanced over the disk.

"The two opposite orders of succession in which the letters are thus presented on the revolving disk, are equivalent to those of the winds which are presented to separate observers on the two opposite sides of the storm. This then being the law of rotation, it follows, that if the general course pursued by a storm be known, two rough observations of the order of changes in the wind, one on each side of its axis path, may be quite sufficient to determine its revolving character; provided that the early and later winds near the axis path have blown transversely to the course of progressions; to determine which, even the same observations may suffice."

Perhaps a still more simple way of understanding this may be given, and it is as follows. If we look at a carriage wheel going fast over a muddy road, we shall see that while the whole wheel (the body of the storm, or *Cyclone*) moves forward on the road or track the dirt

on the upper rim is thrown forward and that on the lower rim backwards. If we suppose arrows (wind-arrows) painted on the felly of our wheel, and that it was a disk of air a mile or two high* moving horizontally over a mass of water, we shall at once see how the different changes take place to ships on opposite sides of the storm circle.

With these explanations of our *words* we shall better understand the *things* spoken of, and in the following parts of the work the proofs of these various definitions will be found.

22. **Various Theories** as to the motions of the wind, and of the body of the Hurricane or Storm (*Cyclone*), and briefly as to the causes of them.

A theory is, as already explained at first, a *supposition*. It obtains proofs by continual observations, and by experiments when these can be made,† and then we set it down as a Law. The principal Theories of Storms—that is of the motion of the wind in them, and not as to what causes this motion—are,

a. That of Mr. **Redfield** and Colonel **Reid** already explained (12 and 13.)

23. *b*. That of Mr. **T. P. Espy**, of Philadelphia, supported by Professor **Hare** and some other American philosophers. These gentlemen maintain that in hurricane storms (Cyclones) the winds do not blow *round* a circle, but *inwards from the circumference of a circle to its centre*, or to a space along a line in the direction of the storm's progress; for they agree with **Redfield** and **Reid** in the fact of the progressive motions of Storms; so that looking at the Compass card one may suppose 32 or 64 or 128, winds! all blowing at the same time inwards to the pivot! or to the needle if it lies in the track of the storm; being one for every point, one for every half, or one for every quarter point, and they affirm that it is this which produces the calm at the centre.

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* See Part IV. at the section on the Barometer for the height of storms above the surface of the Ocean, and for another simple and practical demonstration of the movement of winds in a rotatory storm (Cyclone.)

† We *have* had some experiments made in hurricanes, (Cyclones), and very curious and convincing ones they are, as will afterwards be seen.

They suppose, as we do, this centre to be moving onwards, so that if moving North, for instance, it must as it were annihilate more or less all the winds from, say NW. to NE. as it advances; and apparently to obviate this difficulty amongst others, they suppose that at or near the centre, or central line or axis, the wind curves upwards, and that thus the centre is a huge funnel or chimney, like the base of a water spout.*

24. Mr. **Redfield** also admits of or supposes *some degree* of upward (spirally upwards) curving of the winds at the centre, but this may easily be admitted without any great violence to our notions. Mr. **Thom,** while agreeing with **Reid** and **Redfield** as to the circular motion of the wind at the surface, thinks there is an up-current always formed, and in a figure given in his work this is delineated. The difficulty in this respect in Mr. **Espy's** and Mr. **Thom's** theories is to conceive what can become of the enormous volume of air, and why it does not at least carry the rain upwards? if not the ships or their masts and yards?

25. **Various Theories as to the Causes of Circular Storms.** The seaman must be careful not to confound here as is often done the CAUSE with the *effects* of hurricanes, and hurricane storms (Cyclones.) We can readily suppose a beginning somehow and somewhere, but when we inquire into the *Causes* of the storms we go back beyond this, which is but *the beginning of the effect*, to look for the cause of that effect, or in other words we enquire in plain language thus—"By which one, or more, of the known (or any unknown) powers of nature; as the force of winds, electricity, heat evolved by condensation of the vapour in the atmosphere, &c. &c., is this hurricane (Cyclone) set a-whirling and moving along"? My limits and the object of this work do not allow me to go into much detail on this subject, and indeed to do so would but be to discuss

* The complete contradiction of this theory is found in the fact that, in numerous well attested cases where the track of a storm has been perfectly ascertained, the shift of wind for ships on its direct path has been *perpendicular* to, or across, and not *right against* the track, which Mr. **Espy's** theory requires it to be: See also the case of the "Charles Heddle," and the experiment of the "Hindostan" Steamer, subsequently alluded to.

what are yet but plausible theories—some of them probable ones it is true—and would suppose my readers also more conversant with the chemistry of the atmosphere and the higher researches of meteorology than most of them probably will be.

26. Mr. **Redfield** who, as already shewn (§ 7 p. 3) is the father of the research in recent times, had no particular theory as to the *causes* of circular storms (Cyclones.) He thought that our knowledge of their effects was not far enough advanced, and that it was unscientific to attempt to account for them till better informed by the exclusive action of any one or more causes. In his late publications he inclines to think them produced by the conflicts of prevailing currents in different strata of the atmosphere giving rise to circular movements which increase and dilate to storms.

27. Col. **Reid** avoids any general speculation as to the causes of Hurricane storms, (Cyclones.) He adverts to the possibility of there being some connection between storms and Electricity and Magnetism (Law of Storms, Chap. XII.) but goes no farther than to detail an experiment which appears, he thinks, partially to confirm his views.

28. Mr. **T. P. Espy** in America, has published a thick volume, entitled the "Philosophy of Storms," in which he lays down as before noted (§ 23 *b* p. 13) a theory of the *effects* and one of the *causes* of storms. This last is, as briefly as can be explained, this—First, that upon any partial heating of the air at the surface of the globe it rises in columns more or less charged with vapour, which as they rise condense this vapour into clouds or rain.

Next, in this changing of state the vapour communicates its *latent caloric** to the surrounding air, which also expands, is cooled itself by that expansion, but gives heat to that part of the air in which it then is; and becoming lighter is carried farther up, so that what Mr.

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* The scientific (chemical) term for a quantity of heat which all bodies contain, and give out when passing from one state to another which is *less fluid*, i. e. more condensed, as water passing to ice. If the process is reversed, that is, if the body passes from a *more* condensed state to one *less* so,—as water into vapour or steam—then heat is *absorbed* by it to form *latent* caloric, or heat not shewn by our instruments.

Espy terms an up-moving column (or columns) is always thus formed before rain is produced; and the air, rushing in to supply the partial vacuum at the base of this chimney-like column, forms thus the centripetal (moving towards a centre) streams of wind, which as described (§ 23, *b* p. 13) is, he affirms, the true motion of the wind in all storms, and especially in hurricanes (Cyclones) which are thus not curved and nearly circular as we suppose, but straight-lined winds according to his theory. To put this in plainer words, he conceives the calm centre or lull of a hurricane (Cyclone) to be the base of a huge moving chimney, circular or of any longitudinal shape, the draught of which is occasioned by an extensive condensation of vapour above. He accounts for the production of clouds, the rise and depression of the Barometer, &c. by this cause, inferring that at a certain height the rising air *overflows* the rest of the atmosphere, forming a ring or annulus of cloud and vapour and air, which pressing on that below occasions the rise of the Barometer found at the edges or approach of storms. To examine critically this and other theories, is not the object of this work.

29. Mr. **Thos. Hopkins**, of Manchester, in a work published in 1844, entitled "On the Atmospheric changes which produce Rain, Wind and Storms," and which contains many novel, highly interesting, and lucid common-sense views, admits with Mr. **Espy** and other meteorologists who had long preceded him,* the ascent and condensation of vapour in the air from various causes, and that all horizontal winds are thus produced. He considers moreover that these ascending winds produce *descending* ones, and that the rain produced in the higher regions brings air and steam† (vapour) with it

* The original view is that of Daniell, who was the first to announce the important part which the latent caloric (see Note, p. 15) of the vapour, must perform in all atmospheric changes.

† Mr. Hopkins constantly and properly uses the word "steam" for the "vapour" of Meteorologists in general, who, if they object that *steam* induces the idea of heat, should recollect that *vapour* is the name of water and other bodies which have *not* changed their chemical state. Mr. Hopkins' Steam is the invisible vapour of a fine day which gives the dew point. The vapour of the Meteorologist should be confined to fogs.

in its descent, and thus constitutes lower atmospheric currents. And finally, that storms are produced by the same causes that produce other winds, and that the greatest storms *are descended winds.*

30. Dr. **Alex. Thom**, H. M. 86th Regt., author of a recent work "On the nature and course of Storms in the Indian Ocean, South of the Equator," &c. is of opinion, with respect to this tract, that the principal cause of the rotatory motion of storms (Cyclones) is, at first, opposing currents of air on the borders of the monsoons and trade winds, which differ widely as to temperature, humidity, specific gravity and electricity. These, he thinks, give rise to a revolving action which originates the storm, which subsequently acquires "an intestine and specific action involving the neighbouring currents of the atmosphere, and enabling the storms to advance through the trade wind to its opposite limits;" and he give a diagram to show how this may occur. He farther inclines to believe that "as the external motion is imparted to the interior motion of the mass, and centrifugal action begins to withdraw the air from the centre and form an up-current the whole will soon be involved in the same vortical action." The up-current he explains as being formed by the pressure being removed from the centre, when the air there "increases in bulk, diminishes in specific gravity, and its upward tendency follows as a matter of course."

31. There is however another point of view in which some writers have considered the formation and continuance of these tempests (Cyclones). They suppose them, as Mr. **Thom** does, formed by opposite currents of air producing whirlpools as in water, but they do not consider with him, that they are produced at the *edges* of the streams as we see in water whirlpools. These authors incline to the belief that the whirls originate between the upper and lower *surfaces* of strata of air of different temperatures, degrees of moisture, &c. and moving in different directions. These whirls they suppose first formed above, and then to descend to the surface of the earth, just as we see a water spout begin at sea with a slight swelling of the lower part of a cloud and then a gradual descent of it. In a word, they look upon hurricanes as *wind spouts.**

* The Abbe Rochon describing the hurricanes (Cyclones) of the Mauritius 1771, says they are "a kind of water spout which seems to threaten the spot

One writer, **Kaemtz**,* has *seen* these whirls of wind formed, though not quite under the circumstances which we require. Still his description is worth copying as assisting the reader to form an idea of what a first rate Meteorologist considers to be the causes of these phænomena when they occur on the small scale.

First, he says (p. 47) after alluding to the whirls and eddies formed by conflicting currents at their meeting on the edges:—

"In like manner when the NE. wind prevails below and the SW. above violent whirlings are formed at their limits, which descend to the surface of the earth, and are often endowed with prodigious force."

And at p. 116, he describes an instance of the whirlwinds, though not of their descending, as follows:—

"When a moist wind determines an ascending current along the sides of a mountain, it at last reaches atmospheric strata whose temperature is such that the vapour of water is instantly precipitated. This is especially the case when opposite winds meet on the summit. I have often witnessed these phænomena on the Alps—I will content myself with relating in detail the following fact. A very strong south wind was blowing on the summit of the Rigi, and the clouds that were passing at a great height above my head followed the same direction. The north wind was blowing at Zurich, and ascended along the southern flank of the mountain. When it attained the summit light vapours were formed, which seemed desirous of passing over the ridge; but the south wind drove them back, and they ascended toward the north at an angle of 45°, and disappeared not far from the ridge. The conflict of the two contrary currents lasted several hours. A great many whirls were formed at the point where the two winds met; and travellers, who took little notice of the rest of the meteorological phænomena, were struck with this singular spectacle."

32. The following are the different views of Sir **John Herschel** on the Causes of hurricanes (Cyclones), which I copy as abridged in PURDY'S Memoir of the Atlantic Ocean.

"It seems worth enquiry, whether Hurricanes in tropical climates may not arise from portions of the upper currents prematurely diverted downwards before their relative velocity has been sufficiently reduced by friction on, and gradual mixing with, the lower strata; and so dashing upon the earth

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over which it hangs with entire subversion." See **Grant's** History of the Mauritius, p. 173.

* **Kaemtz's** Meteorology, translated by Walker, London, 1845.

with that tremendous velocity, which gives them their destructive character, and of which hardly any rational account has yet been given. Their course, generally speaking, is in opposition to the regular Trade-wind, as it ought to be, in conformity with this idea.--(Young's Lectures, I. 704) but, it by no means follows, that this must always be the case. In general, a rapid transfer either way, in latitude, of any mass of air which local or temporary causes might carry above the immediate reach of the friction of the earth's surface, would give a fearful exaggeration to its velocity. Wherever such a mass should strike the earth, a hurricane might arise ; and should two such masses encounter in mid-air, a tornado of any degree of intensity on record might easily result from their combination."—*Astronomy*, p. 132.

Again: Sir **John Herschel,** in investigating the observations* made at the different Meteorological Observatories that have been established in various parts of the world, has arrived at the conclusion, that there are, at times, barometric waves, or undulations, in the atmosphere, of immense extent: he has denominated them barometric waves, from their being made evident by the fluctuations of the barometer, which, as was before described, exhibits perfectly the weight, and therefore the quantity, of air above the station. One of these waves has been traced as extending from the Cape of Good Hope, through intermediate stations, to the Observatory at Toronto in Canada, under the superintendence of Lieutenant Colonel **Sabine.** As an explanation of the origin of the rotary storms under consideration, Sir **J. Herschel** has proposed the idea, that two or more of these extensive atmospheric undulations, or barometric waves, may, from traversing in different directions, intersect each other, and from their opposing forces cause the phænomena of hurricanes or rotary storms ?

33. Other suggestions have been thrown out, and instances adduced by different writers as to the possibility of volcanoes, and even fires, originating violent circular motions of the atmosphere, and that volcanic eruptions are often accompanied by violent storms and heavy falls of rain there is no doubt. I have myself pointed out—though my published Researches have been confined like those of **Redfield** and **Reid** to the effects, as the sure eventual index to guide us backward to the *causes* of storms—that in the China Sea and Bay of Bengal† there is much to countenance the idea that storms (Cyclones) in some parts of the world *may originate* at great

* See Report of the British Association, 1843-4. vol XI.

† Sixth Memoir, Storms of the China Sea, Journal Asiatic Society, vol. XI. p. 717.

volcanic centres, and I am inclined to believe also that their tracks are partly over the great internal chasms of our globe, by which perhaps the volcanic centres and bands communicate with each other. If we produce at both ends the line of the track of the great Cuba hurricane (Cyclone) of 1844, we shall find that it extends from the great and highly active volcano of Cosseguina on the Pacific shore of Central America to Hecla in Iceland! And in 1821 the breaking out of the great volcano of Eyafjeld Yokul in Iceland, which had been quiet since 1612, was followed all over Europe by dreadful storms of wind, hail and rain. In Iceland the Barometer fell from the day before the eruption till the twenty-sixth day after.* Mr. **Espy** quotes several other cases, and Humboldt for South America, to shew that nothing is better established than the fact of the connexion of volcanoes with rains and storms. PURDY (Atlantic Memoir) also alludes to the supposed focus of sub-marine volcanic action on the Equator, in that sea, as the spot to which the southern extremes of the West Indian hurricane (Cyclone) tracks would tend, if continued. If I advert to these speculations it is with the hope of drawing the attention of intelligent mariners to them.

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* Espy, p. 67-68; not correctly printed.

PART II.

1. WHAT IS MEANT BY THE TRACKS OF STORMS.—2. AVERAGE TRACKS IN VARIOUS PARTS OF THE WORLD.—3. RATES OF TRAVELLING ON DIFFERENT TRACKS.—4. STATIONARY STORMS OR SUCH AS ARE NEARLY SO.—5. SIZES OF STORMS.—6. CONTEMPORANEOUS, PARALLEL, AND DIVIDING STORMS.

34. In explaining the terms used in our new science, I have already said (§ 19 p. 10) that the **Track of a Storm** is the path or line in which it travels, like the track of a ship, and that of the centre is usually meant; and if I repeat this here, it is only again to caution the novice and seaman against confounding the rotatory motion, or whirling round of the whole storm (Cyclone) with the *progressive* motion or moving forward; the line on which this last is done, whether strait or curved, being the track. If we suppose a storm (Cyclone) only to revolve and not to move forward in any way, such a storm would have no track at all. I shall allude at the close of this part to the probability of such storms (Cyclones) taking place, and to the certainty that some have such a very slow motion that we may almost call them *stationary* storms (Cyclones.) In the practical part *(Part III)* I shall shew how the attentive Mariner may often calculate pretty nearly, by the bearing of the centre, veering of the wind, and his run or drift, what the track of a storm (Cyclone) is, and take his precautions accordingly.

35. In speaking of the tracks of storms (Cyclones) for the use of the seaman, I mean of course to allude to their routes at sea. Much stress has been laid, and some part of Mr. **Espy's** theory rests upon what he has deduced to be the track of a storm, (Cyclone) and the various directions of the wind as ascertained on shore. Now, without meaning any discourtesy, if we except some low countries and islands, and on low coasts, it seems to me, speaking as a sailor, sheer nonsense to discuss the question of how *the* wind blows, inland, in reference to any theory which must depend upon the direction of winds for short periods and in storms. For no man can have looked down from an eminence on even a tolerably uneven country—to say nothing of a *very* hilly or mountainous one—without allowing, especially if he is a seaman, that almost every village must have a different stream of wind for its weathercocks; and some of these differing from four to eight points! We have only to look at maps on a large scale shewing the ranges of hills in any country, and especially some modern ones in which the elevations are shewn by what are called *Contour lines*,* to be satisfied of the futility of these data, except for the general purposes of shewing the *averages* of winds throughout the year. Mr. **Redfield** in his recent Memoir on the Cuba and other Hurricanes (Cyclones) alludes also to this difficulty. Am. Jour. Science, No. 1. p. 321. New Series.

36. **Average tracks of Storms.** We are very far indeed from knowing what the average tracks of Storms (Cyclones) in *all* parts of the world are, even in some frequented seas. In unfrequented ones we can at present only reason from analogy and from the evidence drawn from single logs. We trust now in future to the good sense of every right-minded seaman to furnish the labourers in the field with data to trace them out gradually. I proceed to detail what is known in various parts of the world, noting also briefly the tracts of Ocean for which we have but little information. If I notice any inland storms (Cyclones) it is because some of them may become

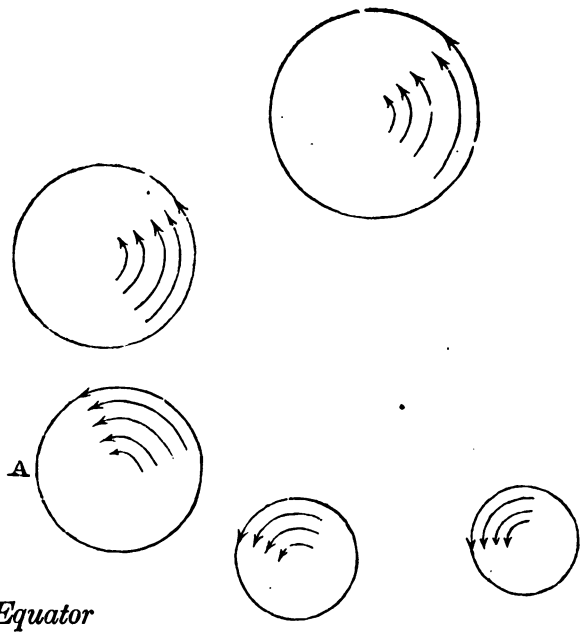
* Lines drawn through all the points of the same height above any given level.

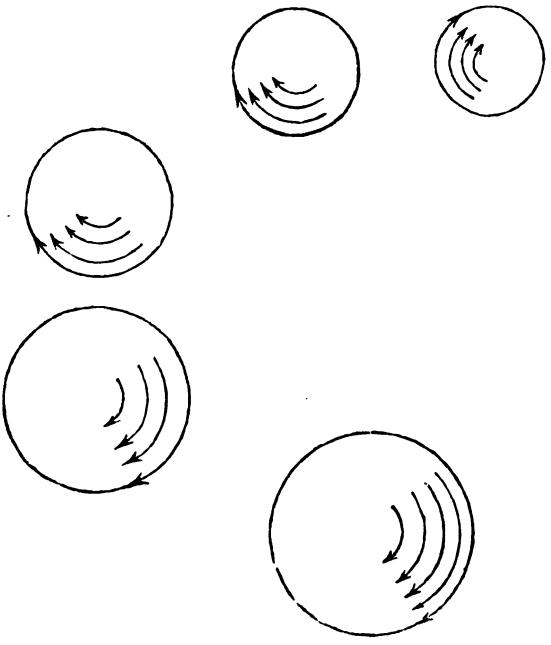
also Ocean storms, and thus interest the Mariner, for whom I am writing, as well as the Meteorologist.

37. Before entering on the details of the tracks of Storms (Cyclones) in various part of the world, as far as they are known, or for the purpose of indicating where they are not so, the seaman should be acquainted with Col. **Reid's**, Mr. **Redfield's** and Professor **Dove's** general views of what *may* be the average system of storm (Cyclone) tracks in both hemispheres; modified of course in a hundred ways by local circumstances, but always *tending* towards the systems they suppose theoretically to exist. The difference between Theory and Law before adverted to (at p. 5, Note) should here be carefully kept in mind, as it is the difference between a probable supposition and a positive rule proved by abundant instances, and this is of importance, because, as we shall afterwards find, the questions of scudding or heaving to, and of profiting or not by a rotatory storm (Cyclone) depend wholly upon our knowledge of the track upon which the storm is travelling.

38. Colonel **Reid** and Mr. **Redfield**, then, suppose that in those parts of the tropics which are nearest to the Equator, the storms (Cyclones) move nearly direct from the Eastward to the Westward; that as they progress they gradually take a more and more Northerly direction in the Northern Hemisphere, and a more Southerly one in the Southern; and then, say about Lat. 20° or 25° North or South, or near to the tropics, they curve more and more rapidly, till beyond them they *re*-curve back to the Eastward again, forming great Parabola-like curves, of which the branches are more or less open according to circumstances. Colonel **Reid** gives the Diagram in the following page to illustrate his view of the *tendency* of the storm (Cyclone) tracks. True rotatory storms (Cyclones) have been traced to Newfoundland in Lat. 48° N. and found yet to be travelling to the E. N. E. and N. E.

The most Southerly storms (Cyclones) we can yet pronounce to have been true rotatory ones are, one in 37° South, and 72° East, of the Ship *Kandiana*, which was travelling to the Eastward, and another in 37° S. and 9° East, of the Ship *Royal Archer*, also travelling to the Eastward, of both of which I have notes.


A
Equator



39. THE WEST INDIES, CARIBBEAN SEA, GULF OF MEXICO, COAST OF NORTH AMERICA AND NORTH ATLANTIC TO THE COASTS OF EUROPE. In this tract we have, thanks to the labours of Mr. **Redfield** and Col. **Reid**, as far at least as the Bermudas, most careful and extensive researches to guide us.

There appears to be (See Chart I.*) two classes of tracks for both the West Indian and the North American hurricanes (Cyclones.) We may conveniently distinguish them as straight-lined and curved tracks. Of the straight-lined tracks of the West Indies one group seems to arise from Lat 10° to 23° North, and (as far as we yet know) to the Westward of 55° West (Tracks F L and M on the Chart.) The most Southern of them (F) travel to the W.N.W. past Tobago and Trinidad, along the Northern shores of South America, crossing the Peninsula of Yucatan, where the traces cease for the present. The next arising farther North, pursue also a W.N.W. course along a line drawn from Barbuda and Antigua to the middle of the Gulf of Mexico, and the third still farther North (M) travels directly to the West from the Atlantic to the shores of Mexico, between Tampico and Matamoras. Between these limits no doubt other straight-lined tracks will be found to occur.

Two more straight (or nearly straight) lined tracks (marked I and J) will be seen on our Chart. These, taking their rise in the interior of the great continent of North America, appear to travel directly out to seaward from about W.S.W. to E.N.E., the Northernmost of them crossing the Lakes and being there the violent and destructive Lake, and Gulf of St. Lawrence storms of November and December.

It will be remarked that those within the Tropic, or the West Indian straight-lined tracks, *come in* from the Atlantic towards the Continent, and between these limits hurricanes (Cyclones) have been observed and tracked (as Track E and the branch of F) which first pursue a straight path, and then, about the meridian of 80° West, curve to the

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* This Chart is from Mr. **Redfield's** to the Memoir alluded to in p. 12 of the Cuba Hurricane of 1844, but some of his tracks are omitted, and I have added one of the Bermuda Hurricane of Sept. 1839, noticed by Col. **Reid.**

Northward, reaching the North Western Coast of the Gulf of Mexico between Matamoras and Mobile.

In a fourth kind of these straight-lined tracks, the storm (Cyclone) appears to form in the Caribbean Sea, or to the Eastward and Westward of Yucatan (Tracks G and H) pursuing a straight or slightly curved track out *from* the Continent to the N. East and E.N. Eastward.

40. The curved tracks are numerous, and appear at times for a large part of their course to be straight, but end by curving more or less.*

They take their rise about 10° to the Eastward of the Leeward Islands,† sometimes as near the Equator as Latitude 10° N. travel to the W. N. W. to a greater or less distance, so as to skirt the Bahamas, or to cross or pass far within the Windward Islands, or even over St. Domingo and across the island of Cuba, to New Orleans. They then curve gradually to the Northward and North Eastward, forming more or less of a paraboloid, and appearing to be mainly influenced by the Gulf Stream; and thus, following the direction of the coasts of Florida and North America, pass out into the Northern Atlantic by an E. N. E. or even more Easterly course between the Bermudas and Newfoundland. Tracks A. B. C. D. and K. comprise the limits within which these storms have occurred, and the seaman from amongst them will have no difficulty in judging of the mean track of those which pass along the Coast at sea; *excluding*

* The seaman will not overlook the scale of our Chart; nor forget that, except where the curves are very sudden, the track is for all practical considerations a straight one, and the object of these general views of the *tending* of the tracks is to enable him, by the methods which I shall explain in the next part, to judge pretty correctly of the path of a storm (Cyclone) when he is a coming into or overtaken by one, and hence to decide upon what may be the best to be done to avoid it altogether; to keep clear of the dangerous centre; or to profit by it.

† The most Easterly origin we yet know for them is that described in Col. **Reid's** work, p. 447, in about 47° West Longitude (Track A.) How much further East they may arise we do not know. See next page for this notice from Col. **Reid's** work.

those which cross the S. West parts of the United States, which become straight-lined tracks when they pass out to the ocean. Col. **Reid,** p. 447, describes a track of much import to the mariner, being that of September 1839,* (A) which was specially a true Atlantic storm, (Cyclone) of which the first ship's notice is in Lat. 20½ N. Long, 47° West, and then successive ones, from others, till it passed close to the Bermudas and reached Nova Scotia and the Gulf of St. Lawrence, but was not felt in any of the Windward Islands, being thus for a great part of its track strictly an Atlantic hurricane (Cyclone).

41. From Lat. 45° N. and about Longitude 50° West—and the storms are usually here dilated to a very large size—they may possibly progress to the shores of Europe, forming extensive S. Easterly, Easterly and N. Easterly gales on their North sides, and North Westerly, Westerly and South Westerly ones on their Southern parts; and by placing the transparent Horn Card for the Northern Hemisphere on a Chart of the Atlantic, the seaman will see how this occurs, and, by moving it along, how ships which meet with such revolving storms (Cyclones) will have the winds. Others may pursue a route farther to the North, and terminate on the Eastern shores of Greenland or between Iceland and Europe.

In Purdy's Atlantic Memoir mention is made of a storm (Cyclone) in the beginning of 1828, in which H. M. Sloops *Avon, Contest* and *Sappho* foundered between the Bermudas and Halifax, the *Tyne* in company weathering it. H. M. brig *Beaver* seems, from this account, perhaps to have accompanied the storm, (Cyclone) or to have run into, or frequently overtaken it on its Southern Quadrants having severe gales from the Westward, and so heavy a sea that she was near foundering, and obliged to heave her guns overboard. This weather "reached Plymouth Sound on Sunday, January 13th, when, shortly after midnight, a violent hurricane came on from the S. W. with vivid lightning and thunder, and 13 vessels out of 21 were driven on shore. Plymouth did not suffer greatly, but the *General Palmer,* East Indiaman, met with threatening weather off Portland,

* He refers to a Chart of it, but I have not that Chart with my copy, nor have I found it.

when a sudden gust or squall carried away all her three masts." This would appear, as nearly as we can judge, to have really been an instance of a storm (Cyclone) travelling the whole distance across the Atlantic. We want, yet, a correct and undoubted tracing of such an instance, and it would be invaluable if we could obtain with it its effects on the currents of the Channel.

At the Azores it would appear from a register supplied by Mr. **Hunt**, the British Consul,* that the tracks of storms (Cyclones) mainly follow that of the Gulf stream, (of which the usual Atlantic current felt there is a continuation,) or to the E. N. E. They are it would appear sometimes deflected hereabouts, but always to the Southward and not to the Northward as far as hitherto known. It is possible that these deflected storms may be at times the Madeira, and even the Canary Island storms, which if not rotatory (Cyclones) rise at least to the strength of hurricanes, or are not far from it.

The Madeira storms which are at times very violent, and those strong but sudden ones often met with between the Meridians of 20° West and the Coasts of Europe, may possibly be sometimes the breaking up of the greater storms (Cyclones) for, as I shall subsequently shew, there is no doubt that rotatory storms (Cyclones) do sometimes divide, especially towards their termination. At times, also, as before said, the great Atlantic storms reach the coasts of Europe from the Burlings and Cape Finisterre to the Channel, travelling to the Eastward,† and the changes and directions of the wind are such as prove their rotatory character. Thus a great circular storm (Cyclone) of 500 or 1000 miles in diameter coming in from the Northward of the Azores E. N. E. to the Channel, might be, at the same time, an Easterly gale at Cape Clear, a Westerly one at Cape Finisterre, South Westerly and Southerly in the Bay of Biscay, and S. Easterly from Ushant across to Cape Clear and in the chops of the Channel. If the seaman will place the Horn Card storm circle thereabouts, with its centre on

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* Nautical Magazine for 1842.

† Or say between E.N.E. or N.E., and E.S.E. and S. East; for we do not know yet their tracks, nor how the approach to the land affects them.

what he may judge the average track, say one to the E. b. N. or E.N.E. upon a general chart of a moderate scale, he will quickly and clearly perceive how this takes place; and perhaps have some suspicion of how a "Bay of Biscay sea" may get up.

42. THE EASTERN COAST OF SOUTH AMERICA, FROM TRINIDAD TO CAPE HORN.—I have met with no information as to whether any true rotatory storms (Cyclones) occur on this Coast, which is but little frequented to the South of the Rio de la Plata; but to the North of it so much so that if any tempests were frequent we should certainly hear of them. Mr. **Luccock** in his notes speaks of a *gale* which began in 34° S. and 200 miles from the land, at N.W. and lasted ten days, drifting the vessel to 36½° South.

43. THE SOUTHERN ATLANTIC FROM CAPE HORN TO THE CAPE OF GOOD HOPE.—Within the limits of the S. E. trade wind in the Atlantic there seem to be but very rarely any storms, and whether these are rotatory or not we have no record for judging. Without the limits of the trade, that is from 28° to 50° South, it is not improbable that rotatory storms (Cyclones) may exist, and that those in the neighbourhood of the Falkland Islands, and in the tract to Tristan d'Acunha and the Cape, may also be at times of that class; though they, no doubt, are, usually, the Westerly gales of the high latitudes. The S.W. gales veering to the N.W. which are experienced to the Eastward of Cape Horn;* and at the Falkland Islands, the Northerly winds veering to the South by the West,† may be parts of rotatory storms, (Cyclones), or of the circuits of wind supposed by Mr. **Redfield**; but we have here, as in so many quarters, every thing to learn. Lieut. **Sullivan** in a paper on the Falkland Islands (Naut. Mag. for 1841,) describes the gales at Berkeley Sound as commencing at N.E. veering to N.W. and ending at S.W. This would indicate a tendency to rotation, according to the law for the Southern hemisphere, and that the track was to the S.S.E. and S.E. as if these islands and the adjacent coast of Patagonia were situated

* American Exploring Expedition, p. 160, Vol. II.

† Bougainville, as quoted by Romme, Vol. II. p. 12.

at one of the curving localities. See subsequent remarks on storms in high latitudes.

44. OFF THE CAPE OF GOOD HOPE AND EASTWARD TO NATAL, it would seem that rotatory storms (Cyclones) certainly exist. They are sometimes, as to extent and duration, though of excessive violence, mere whirlwinds or tornados, but at others of much larger extent and perhaps of slower motion. One of the small ones, a mere tornado as to extent, but a perfect tyfoon as to violence, and which appears to have been travelling to the S. Eastward, overtook and dismasted the French Ship *Paquebot des Mers du Sud* in August 1841, while running in a heavy gale from the Northward, which might have been the Eastern side of the storm circle; for the whole gale (Cyclone), as well as the tornado part of it, certainly veered according to the law for the Southern Hemisphere; and the course of the storm (Cyclone) by a ship which came up with the *Paquebot* the next day was clearly to the S. East.* That is to say, it followed the direction of the prevailing winds and of the theoretical track, as given p. 23, in those latitudes.

45. BETWEEN THE NATAL COAST AND THE MERIDIAN OF THE SOUTHERN EXTREME OF MADAGASCAR,.—From various documents in my possession, I am inclined to think that in this tract the storms will at times be found to travel from the E. N. E. to the W. S. Westward, but they may curve much more to the South. The seaman in crossing it should be watchful and observant in time, so as to be able to estimate from his run and the veering of the wind the probable track of the storm (Cyclone) and avoid its dangerous centre. There is no doubt that, with the Madagascar channel open, the tempests are at some seasons very sudden and excessively severe, but apparently either of small extent, or travelling very rapidly, for they rarely last long.

46. THE SOUTHERN OCEAN FROM THE CAPE TO VAN DIEMEN'S LAND.—I have for this tract also several accounts, from which I entertain no doubt that true rotatory storms (Cyclones) some-

* See 5th Memoir on the Law of Storms, Jour. As. Socy. Vol. XI.

times prevail, and that they travel from the West to the Eastward. It is possible they may also be at times small vortices (Cyclones) thrown off from the larger ones; for the dividing of storms, or the generating of new ones by the progress, or at the commencement of the main one, and even the occurrence of smaller tornados (Cyclones), within the area of a great hurricane (Cyclone) is I think—and I am supported in this view by Mr. **Redfield** and Mr. **Thom**—indisputable (for the Northern Hemisphere at least), and we look naturally for the same in the Southern one; and this theory will explain the sudden violence and short duration of these tempests (Cyclones), and why the regular Westerly gale seems to return again after them.*

47. SOUTHERN INDIAN OCEAN FROM LONG. 50° EAST TO THE COASTS OF AUSTRALIA, AND FROM THE EQUATOR TO LAT. 30° SOUTH.

This space which we can only designate vaguely, and part of the storms of which (those of the Coasts of Australia) will be referred to under another head, will be found comprised in Chart II.

In considering this Chart the seaman should observe, as before said, that its object is not so much to lay down any exact track as to shew him the *tendency* of the paths of the usual storms (Cyclones) with, at times, those which are irregular, and thus to aid him to form his judgment of that in which he may be involved, or near to which he may suppose himself to be. Though the greater part of the tracks have been laid down from the logs of single vessels, yet he may be satisfied that they are quite correct enough to serve this purpose, and where the logs have been so vague and ill kept as to prevent any correct judgment being formed, or where the hurricane (Cyclone) itself has appeared to have but a very little progressive motion, small wind-circles have been introduced, to shew that it is either uncertain as to its track, though certainly revolving, or perhaps a *stationary* storm† (Cyclone), which last class will in some parts of the world be found much more common than is yet supposed, and my object in some cases where these wind-circles are marked has been to put the

* See also Part III. in which these views are more practically considered.

† Subsequently described.

Mariner on his guard against them, and against the small tornado hurricanes: for such some of them may be called from their apparently limited extent. Whether these afterwards in any case progress and dilate, or whether they exhaust themselves and break up not far from the spot where they are raging (and they seem to do both at times) we have yet to learn. What is certain is, that with very brief warning they are violent enough to dismast a vessel, and from dismasting to worse mischief the interval is not great; and such mischief it is our object to avert. I have data for several more storms, but as they fall within the limits and move in the directions of the average tracks given, their insertion on the Chart would only crowd it without assisting the Mariner in his judgment. This will also account for my omitting some from Mr. **Thom's** Chart. The following is the Table of references to the Chart, which are too numerous to be placed upon it.

REFERENCES TO CHART No. II. THE SOUTHERN INDIAN OCEAN.

		Authority.
I.	Track of Rodriguez Hurricane,	Mr. Thom.
II.	Average Northern limit of Hurricanes,	Mr. Thom.
III.	——— Southern limit,	Mr. Thom.
IV.	Track curving to the Southward about Mauritius, Blenheim 1807,	Mr. Thom and Col. Reid.
V.	About Mauritius and Bourbon,	Mr. Thom.
VI.	Curve of the Culloden's Hurricane, March 1809,	Col. Reid.
VII.	H. M. S. Serpent, Feb. 1846,	H. Piddington.
VIII.	Futtle Rozack and other Ships, Nov. 1843,	H. P. in 11th Memoir, Jour. As. Soc.
IX.	Charles Heddle's Storm, March 1845,	H. P. 13th Memoir J. A. S.
X.	Fr. Frigate La Belle Poule and Corvette Le Berceau, Dec. 1846,	H. P.
XI.	H. M. S. Albion, Nov. 1808,	Mr. Thom.
XII.	H. C. S. Bridgewater, March 1830,	Col. Reid and Mr. Thom.
XIII.	H. C. S. Abercromby, Jan. 1812,	Mr. Thom.
XIV.	Maguasha, Feb. 1843,	Mr. Thom.
XV.	H. C. S. Ceres, —— 1839,	Mr. Thom.
XVI.	Timor and Rottee Storm, April 1843,	Mr. Thom.
XVII.	Malabar, Jan. 1840,	Mr. Thom.
XVIII.	Boyne, Jan. 1835,	Col. Reid.

		Authority.
a.	Mauritius, March 1811,	Col. Reid.
b.	———, Feb. 1818,	Mr. Thom.
c.	———, Jan. 1819,	Mr. Thom.
d.	H. C. S. Dunira, Jan. 1825,	H. P.*
e.	H. C. S. Princess Charlotte of Wales, Feb. 1826,	H. P.

* This and several more from a large series of Logs furnished to me by the attention of the Hon'ble Court of Directors of the East India Company.

		Authority.
f.	H. C. S. Orwell, Feb. 1827.	H. Piddington.
g.	Thalia, April 1827,	H. P.
h.	H. M. S. Boadicea, April 1827,	H. P.
i.	H. C. S. Macqueen, Jan. 1827,	H. P.
j.	——— Buckinghamshire, Feb. 1828,	H. P.
k.	——— Princess Charlotte of Wales, March 1828,	H. P.
l.	——— Reliance, Jan. 1831,	H. P.
m.	American Ship Panama, Jan. 1832,	Mr. Redfield.
n.	Mauritius and Duke of Buccleugh, Jan. 1834,	Col. Reid & Thom.
o.	Neptune, Feb. 1835,	Col. Reid.
p.	Thomas Grenville, Jan. 1836,	H. P.
q.	Northumberland, March 1839,	H. P.
r.	American Whaler, Feb. 1839,	H. P.
s.	Exmouth, Moscow, &c. May 1840,	Thom.
t.	Kandiana, Sept. 1840,	H. P.
u.	Mauritius, April 1840,	Thom.
v.	William Nicol, May 1842,	H. P.
w.	Barque Tropic, March 1842,	H. P.
x.	——— Elizabeth, April 1844,	H. P.
y.	Unicorn, October 1844,	H. P.
z.	Dorre Island, Capt. Grey, Feb. 1844,	Thom.
aa.	Swan River H. M. S. Beagle, May 1844,	Naut. Magazine.
bb.	Houtman's Abrolhos, May 1840,	Naut. Magazine.
cc.	H. M. S. Beagle (position uncertain) Nov. 1840,	Naut. Magazine.
dd.	Candahar, Nov. 1842,	H. P.
ee.	Tigris, April 1840,	H. P.
ff.	Earl of Hardwicke, Feb. 1839,	H. P.
gg.	Windsor, Feb. 1837,	H. P.
hh.	French Ship Archibald, March 1846,	H. P.
ii.	Orient, Duncan, and Fr. Ship Grand Duquesne, March 1846,	H. P.
jj.	Maria Somes and American Ship Loo-choo, March 1846,	H. P.
kk.	Manchester, Jan. 1847,	H. P.
ll.	H. C. S. London, Feb. 1827,	H. P.

From the above, the researches of Col. **Reid**, Mr. **Thom** and my own, and much material that I have yet unpublished, we can speak with great confidence of the usual tracks of storms over this great extent of Ocean, as being generally from the E.N.E. to the W.S.W., but from Long. 80° East, and particularly when approaching the Mauritius group * having a tendency to curve to the Southward and sometimes even, according to Colonel **Reid's** results, *back* to the E.S.E.†

While this work is printing I find in a newspaper, the *Mauritien*, copied from the *Hebdomadaire* of Bourbon, an account of a hurricane

* Rodriguez, Mauritius and Bourbon.

† Mr. **Thom** differs from Colonel **Reid** in this view. From a close examination of the documents, I agree entirely with Col. **Reid**; and while preparing this work for the press, I received a report from Commander Neville of H. M. S. Serpent, detailing a storm in 27° South 64° E., from which he

(Cyclone) between the Island of Bourbon and the Island of Sainte Marie, on the East Coast of Madagascar, which gives us another track for that locality. The French Frigate *La Belle Poule* was overtaken by a hurricane (Cyclone) in the night between the 15th and 16th December 1846, or rather she seems, as far as one can judge from a newspaper notice, to have partly run into it; being bound *from* Bourbon to St. Marie, where her fair course was about W.N.W., the wind gradually increasing from the S. E. with a falling barometer, till it became of hurricane violence, blowing every thing to pieces, then ceasing with a calm of an hour or two, and recommencing again with terrible fury from the N. West, at which point it seems to have abated after completely disabling the Frigate. The Corvette *Le Berceau* in company with her appears to have foundered. This hurricane (Cyclone) occurred about 50 leagues from the Island of Cape St. Marie, and thus nearly midway between that port and Bourbon, and the shift described would give a track from about N.W. to S.E. for this locality. It will also be seen by reference to the chart, Tracks IX. and X. that the storm of the *Charles Heddle* in the same locality, which will be subsequently referred to, had about the same tendency to the S.W. The one, Track IX. is laid down as traced in my 13th Memoir, the other is made a little more Easterly and Westerly to allow room for the figures, and the seaman will understand that both these, as before explained, show that the *average* tracks, as far as we yet know, are as here delineated.

47. Between the Latitudes of 5° and 25° South and the Longitudes of 75° and 105° East, is a space where, from some as yet unknown cause, frequent hurricanes (Cyclones) appear to arise, and to progress from thence, at first slowly and then more rapidly; their little progression, or uncertain tracks, entitling them almost to be called *stationary* storms. Col. **Reid** thinks the *Albion's* storm in

escaped by heaving to in due time, of which the track (No. VII.) was certainly from about N. 16° West to S. 16° East, and it is within 8° of the spot where the curving of the Culloden's storm is marked on No. VIII. of Col. **Reid's** Charts. The Serpent's was one of the small tornado-like storms, and moving with great rapidity. Other tracks showing at least the *tendency* to curving will be seen on the Chart.

from 5° to 15° South, and 80° to 90° East, one which may have been in its first commencement at least, "floating with an irregular motion as water-spouts do in calm weather." A storm in this tract in November 1843, investigated by myself* from the logs of numerous vessels, moved up first from the S.E. to the N.W. for two days very slowly, and then curved abruptly away to the S.W., its mean rate not exceeding $2\frac{3}{4}$ miles per hour, and for the first 2 days only 2 miles.

Mr. **Thom** inclines to think that many more of the Mauritius storms take their rise hereabouts, and travel the whole distance. We have not, I think, sufficient evidence for this inference, though there is nothing impossible in it, and some of Mr. **Thom's** storms are traced a long way.

Within this storm tract, and I suspect also within other hurricane (Cyclone) tracts, there appear at times also to occur, as already noticed, and as will be subsequently quoted for the Bay of Bengal, violent little tornado-like storms (Cyclones) which, for the time they last, are true hurricanes as to strength, and if taking an unprepared ship and at night might be fatal to her. The H. C. S. *Rose*, Capt. **Palmer**, on the 25th August 1815, in Lat. 9° 55′ South, Long. 87° 35′ E. from a fresh gale at N.E. at noon had a calm of half an hour, and at 11 P. M. was taken aback by a hurricane at South, which lasted till 3 A. M., carrying away main topmast, main yard, &c. &c., and blowing her boats to pieces against the mizen rigging. The H. C. S. *Macqueen* and *Orwell* (tracks *i* and *f* on the Chart) both experienced severe hurricanes (Cyclones) hereabout, which were travelling from the North in a Southerly direction.

48. STORMS OF THE MOSAMBIQUE CHANNEL AND TO THE NORTH AND SOUTH OF IT. The tracks of two storms investigated by Col. **Reid** and Mr. **Thom** within the northern part of the Channel are all we have, but these seem, like the track of a very remarkable storm in the Andaman sea (see § 54) to follow the usual law of the storms in the neighbouring great ocean, and to move from the E.N.E. to the W.S. Westward.

We have no records of storms to the North of the Comoro Islands, nor to the West of Cape St. Marie, North of its parallel. The hurricanes of the Northern part of the Channel, however, for such

* Eleventh Memoir, Journal Asiatic Society, Vol. XIV. p. 10.

they are as to violence, though perhaps mere tornados as to size, reach Mosambique, and I think even as far North as Zanzibar. At the Scychelles and in the Chagos Archipelago, gales and hurricanes are said to be unknown.

49. From the N.W. point of Australia, Southwards to Cape Leuwin, it would appear that storms of great violence, and these often rotatory, (Cyclones) occur. At Dorre Island in Shark's Bay, we have a good account in Capt. **Grey's** voyage of one which certainly came from the N.E. and was travelling to the S.W. and this is also the first instance we have to record, in the Eastern Hemisphere, of a hurricane (Cyclone) apparently travelling out to sea from a great continent. In the Western Hemisphere we have two instances, Mr. **Redfield's** storms (Cyclones) of November 1835, and December 1839, in which this has occurred, and these hurricanes (Cyclones) have been traced from the interior of North America to the banks of Newfoundland.* To return to the coast of Australia; Lieut. **Wickham,** of H. M. S. *Beagle,* says, Nautical Magazine for 1841, p. 725,

"The West Coast of New Holland is at times visited by sudden squalls resembling hurricanes, as I was told by the master of an American whaler, that in March 1839, when in company with several whalers off Shark's Bay, he experienced some very bad weather without any previous warning, but it was not of long continuance. The gusts of wind were very violent, shifting to all points of the compass, some of the ships lost topmasts, sails, &c. I think the first squall was from N.E., off the land."

The analogy of these with the Ceylon and other tornado-like gales (Cyclones) will strike every one. The storm (Cyclone) marked *dd* on the Chart on the South Coast is one of a like kind, and is described by Capt. **Ridley** of the *Candahar,* as forming with a densely black sky to the W.N.W. in an incredibly short space of time and within an hour, "bursting upon us like a clap of thunder, and blew a perfect hurricane," which lasted for about 15 hours, and must have dismasted the vessel if not prepared, as she was laid with her gunwale in the water. The wind does not appear to have veered more than from W.N.W. to W.S.W., but I have marked this as a hurricane (Cyclone) to put the seaman on his guard hereabouts, as off the Cape of Good Hope.

* I have little doubt that in India we shall also find this to occur with some of the Arabian Sea storms, near the Coast of Malabar and in the Gulf of Cutch.

At Swan River, Lat. 32° South, very severe gales of full hurricane violence are also felt. The anchorage in Gage's Roads is considered as insecure from the N.W. *gales*, as they are called, during the winter. Lieut. **Wickham** of H. M. S. *Beagle*, (Nautical Magazine, 1841, p. 723,) describes one of these storms at Swan River in the year 1838, which evidently was rotatory (a Cyclone), and *came in* from the W.N.W. to the E.S.E. (Track *aa*). He describes also another at Houtman's Abrolhos, Lat. 28° (Track *bb*) in May 1840, which also *came in* from the Ocean towards the land, or from the Westward to the Eastward. We shall subsequently see that from about 20° to 40° S. on the Coast of South America, the storms also appear to *come in* from the Westward.

50. STORMS OF THE ARABIAN SEA.—Including in this title the whole space North of the Equator, to the Coast of Arabia, Persia and Beloochistan, and from the Western Coasts of India and Ceylon to the Eastern Coasts of Africa, I incline to *think* that the storms will be found to travel on tracks from between the N.E. and S.E. to the N.W. and S.W. This opinion I should however state, is one founded more on analogy than on investigation, for I regret to say, that hitherto I have been able to obtain materials for the full investigation of two storms only,* and these seem to have come from the E.S.E., and have travelled to the W.N.W. and N.W. We have very much to learn in this most important sea, being as it is the highway of the steamers from India to England, and subject both on the coast and to the Westward of the Laccadives to severe hurricanes (Cyclones).

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* 8th Memoir, Journal Asiatic Society, Vol. XII., and 14th Memoir, Journal Asiatic Society, Vol. XIV. Since this was written, I have obtained by the attention of the present Governor of Bombay, The Honorable **G. R. Clerk**, and the Chamber of Commerce materials for the investigation of a furious hurricane (Cyclone) in April 1847, in which the H. E. I. Co.'s Steamer *Cleopatra* foundered, and the *Buckinghamshire* and other vessels were dismasted or stranded, and a vast number of native craft were destroyed. From a cursory survey of these documents, I am inclined to believe that this hurricane (Cyclone) was at first stationary between Cape Comorin and the Head of the Maldives, and then that it travelled up in a N. N. Westerly direction between the Malabar Coast and the Laccadives as far as Goa, sweeping two of the Islands, Underoot and Kalpeni with an awful Storm-wave in its progress.

51. Storms of the Bay of Bengal.—I have investigated a considerable number of these, and have published part of my investigations in eleven Memoirs in the Jour. of the As. Soc. of Bengal, and I have much yet unpublished. The result however of these pretty extensive labours, as shewn on Chart III. is, that in the Northern and N. Western parts of the Bay, the storms travel from between E.N.E. and East round to S.E. and even S.S.E. towards the opposite points of the compass. The rhumbs between E. and S.E. however seem by far the most usual; those to the Northward of East, or nearer to the meridian than S.E. *b.* S. seem to be comparatively rare.

52. Between the Andamans and Madras the tracks appear usually to be nearly from S. East and East to the Westward and Northwestward; but when storms (Cyclones) occur in about 6° or 8° of Latitude North, and to the Eastward as far as 90° East, they seem first to travel up from the S.S.E. or S. E., and then to curve away to the Eastward towards the Coast of Ceylon, or the Southern part of the Coromandel Coast; though sometimes such storms (Cyclones) travel almost due East* or E.b.N. from Long. 90° to the Coast of Ceylon. As yet we do not know if the tracks are influenced by the monsoons, and are thus more inclined to particular quarters according to the season of the year; and this is one of many subjects for enquiry.

53. Off the Coast of Ceylon there appears at times to form a sort of very violent but confined storm (Cyclone), though a true hurricane, (Cyclone) as to rotation, but which rather deserves the title of a tornado-storm from its size: these *may* come in from the middle of the Bay, but I suspect that they are sometimes formed very suddenly not far from the shore towards which they travel. The tracks marked X. 2 *b.* and *c.* are instances of these; *c.* is that of a tornado in which H. M. S. *Sheerness* was blown from her anchors, and bilged on the rocks in Trincomalee harbour! in January 1805, (Asiatic Annual Register, Vol. VII.) About Cape Negrais also these little tornado hurricanes are met with, and are excessively violent; one traced by me, that of the *Cashmere Merchant* (marked on the Chart II., 5th Nov. 1839), travelled from the S.S.E. or S.b.E. to the Northward.

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* See 14th Memoir, Journal Asiatic Society, Vol. XIV.

54. THE ANDAMAN SEA.—This tract, confined as it is, is yet subject to hurricanes (Cyclones) of terrific violence, though they must be of rare occurrence, for I have met with no record, nor have I heard of any one suspecting even their existence, till the wrecks of the Runnimede and Briton transports in November 1844, which I was fortunately enabled fully to investigate,* shewed that at times hurricanes (Cyclones) fully equal to those of the China Sea or Bay of Bengal may arise there†.

The track of this storm which apparently took its rise in about 11° North and 96° East, was from the E.S.E. to the W.N.W.

On this and the other Charts the seaman will always note that the wind arrows may indicate, though not positively, about the average tracks in the parts in which they occur.

55. THE CHINA SEA: SEE CHART IV.—In the China Sea, from the result of the analysis of all the records of storms which I could obtain, with the assistance of the Honorable the Court of Directors of the E. I. C., from 1780 to 1841, which will be found detailed at length in my sixth Memoir,‡ and from additional information collected by me and laid down on the Chart to December 1846, it appears, that the *mean* tracks of the tyfoons, for the six months, from June to November, in which they occur,§ are as follows:—

In June, the tracks are from between S. 30 East and East to West.‖

In July, the tracks are from between N.E. and S.E. by E. to the N. Westward.

In August, the tracks are from between East and S. 40° E. to the Westward and N. Westward.

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* 12th Memoir, Jour. Asiatic Society, Vol. XIII.

† Proving that a wide extent of sea is by no means necessary for the development of these meteors in their most violent form, though of very small extent.

‡ Journal of the Asiatic Society, Vol. XI.

§ I have found as yet no record of a tyfoon occurring from 1st December to 31st May, in the China Seas.

‖ On the 27th and 28th June 1846, the H. C. Steamer Pluto ran into a terrific tyfoon, in which she nearly foundered, the track of the storm (Cyclone) was about from the S. 30° E. to N. 30° West.

In September, the tracks are from between N. 60° E. to S. 10° E. to the S. b. Westward and N. b. Westward.

In October, the tracks are from between N. 12° E. and S. 45° E. to the S. b. Westward and N. Westward.

In November, the tracks are from between N.E. and S.E. to the S. Westward and N. Westward, evidently varying with the opposing strengths of the monsoon and trade wind, and probably also influenced by the vicinity of the land.*

Three remarkable curved tracks XXV., III. and *n*, will also be seen on the Chart. These have been laid down on the clearest evidence, and may be taken as nearly correct. Tracks XXVI and XXVII are, though differing so widely, storms (Cyclones) which occurred at the same time; and at their meeting point it is probable that the *Golconda* Troop ship, with 300 Native troops on board, foundered.†

The following is a list of references to the tracks on this Chart.

REFERENCES TO CHART No. IV.—THE CHINA SEA AND ADJACENT PACIFIC OCEAN.

No. of Track.		*Dates.*	*Names.*	*Authority.*
I.	1780.	17th July, ...	H. C. S. London,.....	H. Piddington.
II.	1797.	19th June, ...	H. C. S. Buccleugh,.....	H. P.‡
III.	1803.	20th to 23d Sept....	H. C. S. Coutts, Camden, &c.,.....	H. P.
IV.	1803.	20th September,..	H. C. S. Royal George, Warley, &c.,..	H. P.
V.	1809.	28th & 29th Sept.,	H. C. S. True Briton and Fleet,.....	H. P.
VI.	1810.	29th & 30th Sept.,	H. C. S. Elphinstone and Fleet,.....	H. P.
VII.	1812.	8th & 9th Sept.,..	H. M. S. Theban and Fleet,.....	H. P.

* Horsburgh (p. 280) speaks of "a storm coming out of the Gulf of Tonkin." Now this, to a ship crossing from the Coast of Cochin China to Hainam, is really the Southern half of a great whirlwind, travelling from the Eastward along the South Coast of China, as will be seen by placing the hurricane card on our Chart.

† See 4th Memoir, Jour. As. Soc. Vol. IX.

‡ A large proportion of the data for these tracks I owe to the attention of the Hon'ble the Court of Directors of the East India Company from their records, and several to the kindness of my friend Capt. C. Biden, Master Attendant at Madras, who has been indefatigable for many years in providing me with materials.

REFERENCES TO CHART No. IV.—THE CHINA SEA AND ADJACENT PACIFIC OCEAN.—*(Continued.)*

No. of Track.	*Dates.*	*Names.*	*Authority.*
VIII. 1819.	28th & 29th Oct.,..	H. C. S. Minerva,.....	H. Piddington.
IX. 1820.	29th November,...	H. C. S. Ld. Castlereagh,	H. P.
X. 1821.	18th & 19th Oct.,..	H. C. S. General Kyd and General Harris,..	H. P.
XI. 1822.	14th & 15th Sept.,.	H. C. S. Macqueen,.....	H. P.
XII. 1826.	25th to 27th Sept.,.	H. C. S. Castle Huntley,	H. P.
XIII. 1829.	9th August,.....	H. C. S. Bridgewater,..	H. P.
XIV. 1829.	8th & 9th August,	H. C. S. Chas. Grant, Lady Melville, &c.,...	H. P.
XV. 1831.	23d September,....	At Canton, ...	H. P.
XVI. 1831.	23d October,.....	At Manilla and the Panama's first Storm,....	Mr. Redfield.
XVII. 1831.	24th & 25th Oct.,...	Panama's second Storm,	Mr. Redfield.
XVIII. 1831.	25th & 26th Oct.,...	Fort William,.....	H. Piddington.
XIX. 1832.	3d August,.....	At Canton and Macao,	H. P.
XX. 1832.	22d to 25th Oct.,...	Moffatt;.....	H. P.
XXI. 1833.	28th August,.....	Brigs Virginia and Bee,	H. P.
XXII. 1833.	12th October,.....	H. C. S. Lowther Castle,	H. P.
XXIII. 1835.	3d July,.....	Barque Troughton,....	H. P.
XXIV. 1835.	4th August,.....	H. M. S. Raleigh,.....	Mr. Redfield.
XXV. 1837.	16th to 22d Nov.,...	Ariel and Vansittart,...	H. Piddington.
XXVI. XXVII. 1889.	22d to 24th Sept.,...	Cal. Thetis, London Thetis, & Golconda,	H. P.
XXVIII. 1840.	29th & 30th Nov.,...	French Frigate Magicienne and St. Paul,...	H. P.
XXIX. 1841.	21st July,.....	Hong Kong Fleet,.....	H. P.
XXX. 1841.	26th July,.....	Hong Kong Fleet,.....	H. P.

The foregoing are tracks from the Chart to my Sixth Memoir, "The Storms of the China Sea." (Journal As. Soc. Vol. XI.) The following are mostly from materials since collected, but of which the details are not yet published.

No. of Track.	*Dates.*	*Names.*	*Authority.*
a. 1797.	2d to 4th July,...	H.C.S. Buccleugh, Cuffnells, and Fleet to the W.N.W., ...	H. Piddington.
b. 1797.	8th & 9th July,...	H. C. S. Buccleugh and Fleet to the Northward,.....	H. P.
c. 1797.	16th to 18th July,	H. C. S. Buccleugh, ...	H. P.
d. 1816.	November,.....	Spanish Brig Vigilante,	H. P.
e. 1843.	31st October to 2d November,	Atiet Rohoman & Shaw Allum, ...	H. P.
f. 1843.	31st October,.....	American ship Unicorn, Manila,.....	H. P.
g. 1844.	16th & 17th Nov.,	Ship Edmonstone, ...	H. P.
h. 1845.	10th & 11th Oct.,	H. M. S. Espiegle, Ship Ann and others, ...	H. P.
i. 1845.	6th to 8th Oct.,...	H. M. Steamer Driver,.	H. P.
j. 1846.	28th & 29th June,	H. C. Steamer Pluto,...	H. P.

REFERENCES TO CHART No. IV.—THE CHINA SEA AND ADJACENT PACIFIC OCEAN.—*(Continued.)*

No. of Track.	*Dates.*	*Names.*	*Authority.*
k.	1846. 21st & 22d July,	Ship Hyderee,.....	H. P.
l.	1846. 14th & 15th Sept.,	H. M. S. Agincourt, ...	Mr. J. E. Elliott, Master H.M.S.Agincourt.
m.	1846. 15th & 16th Sept.,	H. M. S. Ringdove, ...	H. Piddington.
n.	1846. 24th to 26th Sept.,	Clipper Mischief,.....	H. P.
o.	1843. Manila, October,	....	H. P.
p.	1831. Manila, October,	....	H. P.
q.	1845. Manila, November,	....	H. P.

56. THE JAVA AND ANAMBA SEAS.—In the China Sea, I have found no record of any Tyfoon (Cyclone) South of Lat. 9° North, nor from thence through the extensive tract which I have entitled the Anamba Sea, lying between Borneo and the Malay Peninsula, Banca and Sumatra, to 3° South, where the Java Sea begins. In the Java Sea itself, during the N.W. monsoon, strong *gales* are often experienced, but whether these are at any time rotatory we cannot yet say.

57. THE BANDA, CELEBES, AND SOOLOO SEAS.—One of these Seas has an open space of upwards of forty square degrees, though as just remarked (§54,) a large space is by no means indispensable to the production of the most violent hurricanes, and in reference to this and the Anamba Sea, as we shall subsequently shew, for the Pacific Ocean at least, rotatory storms (Cyclones) may occur close to the equator! We do not know of any true hurricanes (Cyclones) occurring in them, though strong *gales* are certainly of more frequent occurrence, than from their vicinity to the equator and land-locked position would be supposed. The numerous volcanoes (see §33 p. 19) with which the Moluccas abound, *may* have some influence on the meteorological phœnomena.

58. THE TIMOR SEA.—This great, and yet imperfectly known extent of Ocean, extending from Java and the N.W. point of New Holland to Torres Straits, is subject to severe hurricanes of a true rotatory character (Cyclones) revolving according to the law for those in the Southern Hemisphere and travelling from the E.N.E. to the W.S.W. or S. Westward; at least those from the meridian of Timor to the westward appear to do so. East of this meridian we

know only of one hurricane (Cyclone) which occurred at Port Essington, Lat. 11° 22′ S. Long. 132° 10′ E. in December 1839, in which H. M. S. Pelorus was driven on shore, and the new settlement nearly destroyed. It was of small extent though its violence was excessive, and the Barometer sunk to 28° 52′. Its track may have been from the East to the West, or not far from those points.

59. Along the South Coast of Australia to Bass' Straits, though the usual Westerly winds and gales of the higher latitudes in both hemispheres prevail during the greater part of the year, I have no doubt that rotatory storms (Cyclones) also often occur. The *gales* are described as beginning at N.W. with a low Barometer,* and thick rainy weather, increasing at West and S.W. and gradually veering and moderating to the South and even S.S.E.† Sometimes also they return to West or more Northerly, with a fall in the barometer, but the gale is not then over, though it may diminish or die away for a day or two. *Sometimes the wind flies round suddenly* from N.W. to S.W., and the rainy thick weather then continues a longer time. This account is a little abridged from Horsburgh, Vol. I., p. 121‡, and if the Northern half of the Horn Card for the Southern Hemisphere be moved slowly from West to East over a dot marked on a Chart, in about the parallel of 40° S., the usual track of ships proceeding towards Bass's Straits, it will be seen at once how closely the first part of this description answers to the case of a rotatory storm (Cyclone) overtaking and striking a ship with its N. Eastern quadrants, and travelling faster than the ship, or say on a parallel course. The centre is nearest to her when the wind is at West and therefore the gale strongest, and it leaves her with the Southerly winds as it proceeds ahead of her. The case of the renewal of the gale may be that of the ship's overtaking it again, or of another vortex following closely on the first, and the "flying round suddenly" occurs, unquestionably, where the central portion of the storm (Cyclone) reaches the ship. The long duration of the

* 29.5°, or lower.

† With the barometer rising to above 30 inches.

‡ The original is by Flinders, but the reference has not been given in Horsburgh.

storms is doubtless owing to ships usually scudding with them, being a fair wind. All this is however but "*great probability,*" and to make it a full certainty, we should have the logs of Whalers or other vessels in higher latitudes with Easterly gales at the same time. In the Chapter on which I speak of the Storm Wave and Storm Currents, the seaman will find a caution of importance to him when approaching Bass' Straits.

We have no good records for the storms off the coasts of Van Diemen's Land, nor any for those to the North between Bass' Straits and Port Jackson. Within Bass' Straits I find in a review of the voyage of H.M.S. *Beagle,* that Commander **Stokes** says :

" The gales in Bass's Straits begin at N.N.W., and draw gradually by W. to S.W., when they subside. If it backs it will continue, but the barometer will indicate its duration ; it is seldom fine with a pressure of 29.95 in. ; and always bad if it falls to 29.70 in." This exactly represents the Northern half of a circular storm (Cyclone) travelling throngh the Strait from the Westward. The " backing" would be the case of a rotatory storm (Cyclone) passing up from the S.W. to the N.E. and lasting longer, either because its diameter was greater, or because its motion was slower, having been checked in its passage over the N.W. part of Van Diemen's Land, for the passage of storms (Cyclones) over high land certainly checks for a time their rate of travelling.

60. THE NORTHERN PACIFIC OCEAN.—Off the South Coast of Japan we have one account of a storm (Cyclone) by Admiral **Krusenstern** in 1804,* which appears to have been travelling from the Southward due North, as deduced from the shift of wind which he experienced. It was in Lat. 31° to 32° North, that this Tyfoon (Cyclone) was experienced, and in sight of the South Coast of Japan. At Chusan, Lat. 36° N. in Sept. 1843, a severe Tyfoon (Cyclone) was experienced, which undoubtedly came from the S.E. They are said to be uncommon there. In Lat. 27° N. Long. 122° E., or between the North end of Formosa, the Loo Choo Archipelago, Chusan and the Coast of China, I have also a newspaper record of a storm

* Chinese Repository, Sept. 1839.

(Cyclone) experienced by the Ship *Cacique*, in September 1843, in which the shift, with a short calm, was from N.E. to S.W. shewing a track from the S. Eastward to the N.Westward at that season of the year. Our track *n* also, within the Straits of Formosa, which is that of H.M.S. *Ringdove*, in the month of Sept. 1846, is from the S.Eastward, and it will not escape the reflecting seaman that here, as in the corresponding latitude in the West Indies, we have a wide extent of Ocean to the Eastward, on the limits of the trade winds, then a sort of barrier of Islands formed by the Japan, Loo Choo, Typinsan and Formosa Archipelagos, and within these a confined sea of seven or eight degrees in width, and eight to ten in length, bounded by the great Continent of Asia. When we collect more data, we shall be better able to pronounce if the effects of these similar circumstances are also similar; at present we can only notice the probability and regret our want of materials.

Further to the Eastward, at the Bonin Islands, Lat. 27° N. Long. 142° East, tempests of hurricane violence are said to be frequent, and to come from the Eastward.

In the space comprehended between the Philippines, the Bashee Islands, Formosa, and the Loochoo Groupe to the West and North, and the Bonin and Mariana Islands to the East and South, Tyfoons, (Cyclones) are excessively sudden, and certainly come from the Eastward. The ship *Montreal*, of Boston, even experienced "a Tyfoon" in 9° 11′ North, Long. 140° East, which is to the South of the Carolina Groupe.* On the Eastern Coast of the Philippines severe gales are known to prevail, which become true Tyfoons (Cyclones)†.

It will be seen on inspection of the chart, that I have been able to trace, partly from documents now half a century old, but highly authentic, being the logs of the East India Company's Fleet of 1797, of which the *Buccleugh* formed one, and in which H.M.S. *Swift*, foun-

* Memorandum by Mr. **Elliott**, R. N., Master H. M. S. *Agincourt.*

† The Natives of the Philippines, who like all nations of Malay origin are good fishermen, and daring seamen after their own fashion, perfectly distinguish between the tyfoons or turning gales (Cyclones) and the strait-lined, Monsoon gales. They call the first *Bagyo* and the latter *Sigua.*

dered while convoying,* a few tracks, which are again corroborated by that of the Tyfoon (Cyclone) experienced by H.M.S. *Driver*, in October 1845, (*i.*) If we follow these tracks with the eye to the shores of the great island of Luzon, with its extensive chains of lofty mountains, we shall easily conceive how in forcing their way over amongst these obstacles, as well as in passing through the Bashee Passage, many of the storms may be deflected from their course to the North West to one towards the West and S.W. since there is no sort of doubt that curved tracks occur in the open Sea, in the China Sea, Bay of Bengal, Southern Indian Ocean and West Indies.

Hence we may perhaps say for this tract, i. e. from 7° or 8° to 40° North, and from the meridian of the Marianas to the Coast of China and the Philippines, the tracks are from between the S.E. and N.E. to the N.W. and S.W., perhaps with some a little nearer to the meridians, according to the varying state of the Monsoons and Trades, and other causes of which we are as yet ignorant.

Amongst the Marianas and Carolinas storms appear to occur, and in some seasons frequently, but we have no authority except that of analogy, and what I have given above, to pronounce them rotatory (Cyclones) or to deduce their probable tracks.

Of the great extent of Ocean in the Northern Pacific, from the Marianas and Carolinas to the Sandwich Islands and West Coast of North America, we have also but very little notice, and none from which we can deduce the nature or tracks of the storms if they are rotatory; but from what will be presently said of the storms of the Southern Pacific, there seems no reason to doubt that as the same causes exist so the same effects are produced, and that rotatory storms (Cyclones) are found in the Eastern part of the Northern Pacific turning according to the law of their revolutions for the Northern Hemisphere ↻ or against the hands of a watch, and usually travelling on tracks tending gradually to the Northward, until influenced by the West Coast of North America, for which I have been also unable to obtain any data.

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* See Part III, for details of the lesson afforded us now by this dismal event.

61. IN THE TROPICAL REGIONS OF THE SOUTHERN PACIFIC from the Barrier Reefs of New Holland, through the numerous groupes of islands to the Low Archipelago, and perhaps even to near the Coast of S. America, and from the Equator to Lat. 25° S. there is no doubt that true hurricane storms (Cyclones) occur of as great violence at least as those in the Northern Pacific just alluded to; but from the scattered accounts from single ships, or missionary residents on the various islands, we cannot with confidence say any thing positive as to their tracks, though they appear to come from the Eastward amongst the islands, and sometimes to curve to the Southward. The following are a few notes. The seasons at which they prevail seem also to be the same as those of Mauritius and Bourbon.

At Vitileva, in the Fejee Groupe,* in February 1841, a well defined circular storm (Cyclone) tolerably observed, seems to have moved to the Southward, and though it lasted four days was not felt at Tonga, 8 or 10 degrees to the S.E. of it.

At Apia Harbour in the Samoan Groupe, (Navigator's Islands) Lat. 14° S. on the 16th December 1840, a true hurricane storm (Cyclone) of great violence, with a fall of 4 inches of the mercury, (by a damaged barometer) was observed, moving from the North to the Southward, and four years previous, another, also well defined, moving from the N.E. to the S.Eastward, the change of wind being from S.E. to N.W. The space between the Samoan (Navigator's) Islands and Friendly Islands is said, expressly, to be subject to violent *hurricanes*, and that scarcely a year passes without some of the Friendly Islands suffering from them. Their violence is such, that many of the American Whalers, have been made complete wrecks of by them—two were lost in 1842† at the Navigator's Islands.

At the Kingsmill Groupe *on the Equator!* violent storms, which seem to be Tyfoon-like are experienced.

At Vavaoo in the Friendly Islands, Lat. 19° S. Long. 173′ W. in 1837, the American Whaler *Independance*, was driven on shore by "a hurricane," and taken off by the shift of wind.

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* U. S. Exploring Expedition, Vol. iii. p. 321.

† Year uncertain.

The account of the storm at Raratonga, in the Harvey Islands, in 19° S. 160° W., described by Mr. **Williams**, and quoted by Col. **Reid**, gives us unfortunately nothing further than the certainty that hurricanes (Cyclones) prevail there at times.

Mr. **Thom** says, p. 341,—"In December 1842, H.M.S. the *Favorite*, on her way from Tahiti to the Island of Mangeea, met with a storm of a rotatory kind, and so severe, that the vessel was hove to under a main topsail. Capt. **Williams** was warned of a hurricane before his departure, which shews that storms of this kind are familiar to the natives."

62. At New Zealand there is no doubt that true rotatory hurricanes (Cyclones) sometimes occur, and these of considerable violence. In the U.S. Exploring Expedition, Vol. II. p. 381, is a very good account of one which occurred on the 29th February 1840, at the Bay of Islands; said to have been the severest which the Missionaries had experienced there. It was felt at other stations, with all the veerings, calm centre, &c., of a true tropical hurricane (Cyclone) its course being to the S. Westward.* In July, 1840, H. M. S. *Buffalo* was wrecked, on the 28th, in a heavy gale which lasted three days, at Mercury Bay, New Zealand. About that time also three American Whalers were wrecked at Port Leschenault, in one of the strongest hurricanes ever experienced by their commanders.

63. In the great space lying between Van Dieman's Land and Cape Horn, we have scarcely any observations of rotatory storms, (Cyclones) but in a capitally well kept log of the ship *Lord Lyndoch*,

* It is said to have passed between the Bay of Islands and the River Thames, which lie about S.S.E. ½ E. and N.N.W. ½ W. of each other, hence the track may have been either to the Northward or Southward of S.West. Its track to the S.Westward or perhaps S.S.W. after crossing the Island, I am enabled *perhaps* to corroborate from a log in my possession, of the Ship *Adelaide*, which vessel between the 1st and 2d March, about 3½ degrees due West of Cape Egmont, experienced a smart "gale" commencing at about E.b.S. or E.S.E. and veering to S.b.E. reducing her to close reefs with a heavy cross sea. This roughly calculated gives 340 miles for 36 hours, or about ten miles per hour. Commodore **Wilkes** suggests that this New Zealand Hurricane, (Cyclone) may possibly have been the same as that which occurred at the Feejee Groupe, which is very probable.

Capt. **Clapperton,** now Master Attendant at Calcutta, I find that in the month of December 1820, in Lat. 45° South 117° West, a "gale" was experienced which veered from N.W. to S.W. in 14 hours, or about half a point an hour, in which time the ship, standing to the North 60° East, made about 83 miles on that course. If this was a rotatory storm (and the Bar. fell from 29°70, to 29°07,) it passed her to the Southward, on a track a little to the Northward of West, and travelled at the rate of about 15 miles per hour. Judging from the fall and subsequent rise of the Barometer, as well as the veering of the wind, there seems no reason to question that it was so.

64. In a newspaper article copied from the *Sydney Herald,* I find the following extracts and notes, evidently written by some person who understood and was endeavouring to teach the science, but I regret that of a series of papers only a part of one has fallen into my hands. "So completely does the law of rotation appear to be from left to right, in gales of wind off the coasts of Australia and on the neighbouring ocean, that it is scarcely possible to escape the observation, in perusing the log books of any extended cruize. One further example, to show this, shall now be quoted.

"The whaler *Merope,* left Sydney 22nd March, 1840, with wind at the South, steering for Lord Howe's Island. On 27th, she was in 35° 4′ S., E. 158° 35′ E. The order of the wind's changes was as follows: 23d, at S. E. veering N.E.—24th, N.N.E. and N. E.—25th, increasing from N. E., N.N.E., E.N.E. with a tempest,—26th, N. E. to N. with confused sea; N. W. and drawing to W.—27th, S. W. S. S. S. E, and back to S. The wind thus completed a revolution in five days, on a direct course, from left to right.

"Between Australia and America, a similar course is pursued by the winds to that which is followed between the Cape of Good Hope and Cape Leuwin, and more than one instance has come before us, of vessels having been driven *all round the compass before the wind* during a gale, not far from Cape Horn.

"The following examples from Captain **Stokes'** Journal (given in Vol. III., of the *Beagle's* Voyage) shews the general character of the gales on the West coast of America. About the Lat. of 50° S. on 5th April, 1828, a gale came on from N. off Cape Tres Puntas, blow-

ing on 6th, 7th, and 8th, from North, N.W, and S.W., with squalls, thick weather and rain. It abated on 9th, veered to the Southward, and then to S.E., when it ceased. This was *from left to right.*

"On the 10th April, another gale came on from N.W., which as suddenly subsided in the western quarter. This, Captain **Stokes** says, "was singular, for those we have experienced *generally* commenced at North, thence drew round to the Westward, from which point to S. W. they blew with the greatest fury, and hauling to the Southward, usually abated to the Eastward of South," (p. 192). These gales therefore rotate *from left to right.*"

65. It would seem that as to violence at least, hurricanes are felt as far South as Patagonia, where (Nautical Magazine for May 1846,) "a severe S.S.E. hurricane" is said to have "swept the coast" from the Bay of Camaras to the island of Desejada, occasioning the loss of twelve English and American vessels. We do not know if it was rotatory, or what was its track.

66. In the Voyage of Don Juan de **Ulloa** in 1743, speaking of the weather on the Coast of South America,* we find some account of storms which resemble rotatory ones, and the latter part is in fact a description of one. I have abridged the extract a little, in parts unessential to our present subject.

"Tempestuous weather is equally common in the latitudes of 20° and 23° in the South Sea as in the Oceans of Europe. Along the coasts and adjacent seas, the winter begins in the month of June and lasts till October or November, its greatest violence being past in August or September. Storms which arise with great rapidity are very frequent during the whole winter; Northerly winds are very prevailable, and often of extreme violence, raising a tremendous sea. It often happens that these violent North winds, without the least sign of an approaching change, shift round instantly to the West, which change is called the *travesia*,† but continue to blow with the same force. Sometimes indeed this sudden change is indicated by the horizon clearing up a little in that quarter: but in seven or eight minutes after the appearance of this small gleam of light a second storm comes on; so that when a ship is labouring

* I am quoting from a written extract from the English translation, in which the page and volume are not marked.

† A Spanish word meaning Oblique or transverse, used also for a side or contrary wind. The change we see *is* one of eight points as here described.

against the violence of a storm from the N. the greatest care must be taken, on the least appearance to prepare for the *travesia*; indeed its rapidity is often such as not to allow time sufficient for making the necessary preparations, and the danger is sufficiently violent if the ship has her sails set, or is lying to.

"In the month of April 1743, in the latitude of 40°, I had the misfortune of experiencing the fury of a storm at N. which lasted in its full violence from the 29th March till the 4th of April. Twice the wind shifted to the *travesia*, and veering round to the Southward, returned in a few hours to the North. The first time it shifted to the West, the ship by the vortices formed in the sea by this sudden opposition to the course of its waves, was so covered with water from head to stern, that the officers concluded she had foundered, but fortunately we had our larboard tacks on board, and by a small motion of the helm, the ship followed the change of the wind, and brought to without receiving any damage; whereas we should otherwise, in all probability, have been lost. Another circumstance in our favour was, that the wind was some points to the westward of N. for though these winds are here called *Nortes* (Northers), they are generally between the North and N.W. and during their season, veering in some squalls to the North in others to the N.W.; sudden calms also intervene, but if these happen before the wind have passed the *travesia*, it returns in about half, or at least an hour with redoubled fury. These dangerous variations are however indicated by the thickness of the atmosphere, and the dense clouds in the horizon. The duration of these storms is far from being fixed or regular; though I well know some pilots here will have it, that the North wind blows twenty-four hours, and then passes the *travesia*; that it continues there with equal violence three or four hours, accompanied with showers, which abate its first violence; and that it then veers round till it comes to the S.W., when fair weather succeeds. I own indeed that I have in several voyages found this to be true; but at other times I experienced that the successive changes of the wind are very different.* The storm at North I before mentioned, began March the 29th, at one in the afternoon, and lasted till the 31st at ten at night, which made 57 hours; then the wind shifted to the *travesia*, where it continued till the first of April without any abatement, that is, during the space of twenty-two hours. From the West the wind veered round to the W.S.W. and S.W., still blowing with its former violence. Hence a short calm succeeded; after which, it a second time shifted to the North, where it continued blowing with its former fury fifteen or twenty hours; then came on a second *travesia*; and soon after its violence abated, and the next night shifted from S.W. to S.E. Thus the whole continuance of the storm was four natural days and nine hours; and I have since met with others of

* When in a different part of the storm circle.—H P.

the same violence and duration, as I shall mention in their proper place. What I would infer from my own experience, confirmed by the information of several pilots, is, that the duration of these storms is proportional to the latitudes; being between twenty and thirty degrees, neither so violent nor lasting as between thirty and thirty-six, and still increasing in proportion as the latitude is greater.

"These winds have likewise no regular or settled period, the interval betwixt them being sometimes not above eight days; at others much longer; nor do they always blow with the same violence; but are most uncertain in the winter, rising suddenly when least expected, though not always blowing with the same force.

"In this sea a change of the wind from N. to N.E. is a sure sign of stormy weather, for the wind is never fixed in the N. E. nor does it ever change from thence to the E. its constant variation being to the W. or S.W. *contrary to what is seen in the Northern hemisphere.* Indeed in both the change of the wind usually corresponds with the course of the sun, and hence it is, that as in one hemisphere it changes from E. to S. and thence to the W. confirmable to the course of the luminary, so in the other it changes, for the same reason, from the E. to N. and afterwards to the West.

"It is observed, that within thirty or forty leagues of the Coast of Chili, while one part is agitated with storms at N., the S. winds freshen in another. This, however singular it may appear, is no more than what was experienced by the three ships Esperanza, Belen, and Rosa, which being at the mouth of the Bay of Conception, the latter took her leave of them, and bore away with a fresh gale at S. to Valparaiso, whilst the others who steered for the islands of Juan Fernandes, were overtaken in their passage by a storm at N."

The foregoing extract is long, but it is the best authority I have for the tracks. The change from due North to due West, with or without an interval of calm, would indicate a storm coming in from the Pacific and from the N. Westward, supposing always the law of rotation to be the same here as it has been shown to be in other parts of the Southern hemisphere. Don J. de **Ulloa's** own account in the next paragraph, describes accurately enough either two storms (Cyclones) following close upon each other, or a vessel drifted round and round the same vortex, and in the absence of any more detailed account it is impossible to say which it was. The changes are evidently those of a circular storm (Cyclone) of very slow progression, coming in from the N. Westward. And this is farther confirmed by the account of the three ships in the last paragraph. We may therefore

venture to say that the storm tracks between 40° S. and 20° S. between the meridian of Juan Fernandez and the coast of South America, appear to be from the Westward (and *probably* from the *North* Westward) towards the Coasts. See p. 37 for what is said there of the tracks on the West Coast of Australia.

67. From 20° South to the Equator and thence to the Gulf of California, our information is still very deficient. Mr. **Redfield** and Colonel **Reid** incline to think the storms on the coasts of Nicaragua, Guatimala and Mexico are connected with those of the Gulf of Mexico, or perhaps originate there. In a recent memoir,* Mr. **Redfield** says:

"According to Humboldt, both the Eastern and Pacific coasts of Mexico are rendered inaccessible for several months by severe tempests, the Norths prevailing in the Gulf of Mexico, while the navigation of the western (Pacific) coasts is very dangerous in July and August, when terrible hurricanes blow from the S. W. At that time, and even in September and October, the ports of San Blas and Acapulco are of very difficult access. Even in the fine season, from October to May, this coast is visited by impetuous winds from N. E. and N. N. E., known by the names of Papagallo and Tehuantepec.

"It appears in like manner that the coast of Nicaragua and Guatimala in the Pacific, is visited by violent Southwest gales in the months of August and September, known by the name of Tapayaguas, which are accompanied with thunder and excessive rains; while the *Tehuantepec* and *Papagallos* exert their violence during a clear sky.

"This seems to show that the so-called Papagallos, Tehuantepec, and Norther of Vera Cruz, severally, are but the clear weather side of a revolving gale, like the North-wester of the coast of the United States; each in its turn being but part of a great vortical storm, which, in certain other portions of its area, or route, often exhibits an abundance of rain.

"Humboldt suggested that these Northerly winds may blow from the Atlantic and Gulf of Mexico to the Pacific, and that the Tehuantepec and Papagallo, may be merely the effect, or rather the continuation, of the North wind of the Mexican Gulf and the Brizottes of St^a. Martha. But the vortical character and determinate progression of violent gales was then unknown, and I cannot doubt that the Northers which visit the Pacific coast and the Gulf of Tehuantepec precede, in point of time, the same storms in the Gulf of Mexico, and are identical with them, having, commonly in this region, a Northerly progression."

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* American Journal of Science and Arts, March 1846. New Series, No. 1, p. 164.

Col. **Reid** says,

"It is possible that the Spaniards may apply the term Nortes, or Northers, to more than one phenomenon; but the violent North winds in the neighbourhood of Vera Cruz, are frequently no other than the left hand side of rotatory storms, in their Northerly progress across the Gulf of Mexico."* In this remark I fully concur.

68. Of the tracks of storms, and even if any are rotatory (Cyclones) in the European Seas, we have but little information, and in truth this may remind us to be thankful for what is already collected in distant oceans, when we see how little is yet accomplished at our own doors. Beginning then with the Mediterranean, it would appear from the account published by Mr. **Thom**, p. 262, that tornados or tornado-storms are certainly experienced there. The N. Westerly gales in the Gulf of Lyons, those which are at some seasons of the year common in the Ægean, and especially those of the Black Sea, may all be either rotatory or straight-lined winds,† or those which appear to be straight-lined, may in reality be parts of great circles or Cyclones.

On the Coast of Syria from Acre to Beirout and in the Eastern parts of the Mediterranean, the British Fleet on service in that quarter, experienced in December 1840 a most severe gale, which, alluding of course to its strength and not to its rotation, they all call "a hurricane." From the published account of the narrow escape of H. M. S. *Bellerophon*, 74, (Nautical Magazine 1841,) at Beirout, it would seem that the wind veered between 5 A. M. and 9-40 P. M., from S.W. to N.N.W., or 10 points in 16½ hours, which might have been the effect of a rotatory gale (Cyclone) travelling slowly to the E.S. Eastward. Unfortunately, and this is a most vexatious omission,

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* Second edition of "Attempt to develop the Law of Storms," &c. London, 1841.

† And as not very remote we may add to these the Caspian, which from the days of Horace has been noted for its sudden and violent tempests. In Dr. **E. D. Clarke's** Travels, vol. II. of the octavo edition, is an account of a violent storm which he experienced in the Venetian Brig *Moderato*, at the mouth of the Straits of Marmara, (Constantinople) which appears to have been a violent little Tornado storm moving up to the E.b.N. or E.N.E. with some peculiar appearances of "whirling clouds," of which it is to be regretted we have not more details.

the direction of the wind is never given in the other accounts, or but vaguely, so that we are left in much doubt about this storm, and about the winter gales of the Levant in general.

The accurate knowledge of this would often be of great utility. At present we cannot even pronounce that the storms of the Mediterranean are rotatory, and it is therefore idle to speculate on their tracks.

In the Channel, Irish Channel and German Ocean, and perhaps in the Baltic, we have some disjointed evidence of the heavy gales being at times rotatory and coming up from the S.E. and unquestionable Hurricanes (Cyclones) both as to their violence, veering, calms and shifts, have been met with in the Chops of the Channel, though of small extent.

The general tendency of all the evidence is to show that they come in from the West and S. West, and travel to the East and North East, but here again our knowledge stops for the present.*

69. **The average rates at which Hurricanes (Cyclones) travel on different tracks** is also an essential part of the seaman's knowledge, to enable him to form the best judgment of how he may avoid or profit by a storm (Cyclone.) These rates vary greatly, not only in various parts of the world, but even in the same localities, and at the same season; nor does the size of a hurricane afford any rule whereby to estimate its rate of travelling, as both large and small ones are known to move with great rapidity, or at moderate or slow rates without, apparently, any sort of law. It has been conjectured that the vortex below was carried forward by currents of wind above, as we see waterspouts move with the clouds from which they proceed; but it is objected to this, that the upper strata of clouds are

* And until the Science is made, as it assuredly ought to be made, as much a matter of National research as the Trigonometrical Survey or other establishment of the kind, it is to be feared it will for a long time make but little progress. If we were even to suppose a sailor of independent fortune, and with all the required talents, devoting himself to the research, he would still want the influence to persuade, and oftener the power to *demand* reports and returns; and would in all probability, when writing from London to Oporto, Archangel Alleppo or South America for data of great importance, find that his requests were useless unless he had an agent on the spot.

often seen, through breaks in the storm, to move across or against the track of the hurricane* (Cyclone.) We are thus as yet as entirely in the dark as to what causes their progressive motion, as we really are as to what gives them their violent gyrations; and we are still more so, if we consider that like sand-storms or dust whirlwinds, some of them appear to remain comparatively stationary for hours or a day or more (see p. 34 § 47,) moving at a rate of 1-5 or 2 miles an hour, and then to start off, as it were, on a track upon which their size and velocity gradually increase! We find them also usually much diminished in their velocity when they pass over land, especially if it be high, and it would appear too that storms sometimes *decrease* in size and in rate of travelling, but augment fearfully, in so doing, their violence,† and this when passing over the open ocean.

It is then quite impossible to say to what their progression is owing, but the seaman will not fail I trust to recollect that all his observations may be useful to those who are ready to turn them to the best account, if he will but register and communicate them; and that what may appear to him at the time, a very insignificant occurrence may, by chance, aid greatly in working out this mysterious branch of the research. In giving the rates, then, at which storms (Cyclones) travel, as far as yet known, I shall follow the order in which I have described their tracks, passing over localities in which we have no good data for their rates of travelling.

70. In the West Indian and North American storms (Cyclones) the highest rate given by Mr. **Redfield** is 43 miles per hour,‡ and the lowest 9.5 miles. The mean rate is thus 26 miles, which last or perhaps from 16 to 20 miles per hour should always be taken as the lowest rate at which a storm in this part of the world *may* be moving.

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* Which itself has a track against the prevailing winds, as in the Atlantic hurricanes moving to the N.E. *against* the Trade; or oblique to them, as the hurricanes of the Southern Indian Ocean moving to the W.S.W. *across* the S.E. Trade, and those which occur in both monsoons in the Bay of Bengal and in the China Sea also moving obliquely, or at right angles to it.

† A well marked case of this occurred in the Bay of Bengal in Nov. 1839, when Coringa was devastated by a furious hurricane (Cyclone) which was traced from the Andaman Islands across the Bay. Jour. As. Soc. vol. ix. p. 438.

‡ The Cuba Hurricane of Oct. 1844.

The Atlantic Storm, noted at p. 27, appears to have travelled at about 11.4 miles per hour.

71. In the Southern Indian Ocean Mr. **Thom** considers that the rates of travelling may be from 9 and 10 to little more than two miles per hour, and that the diminished rate occurs about where he supposes the storms to terminate near the Southern tropic, and on the meridians between Madagascar and the Mauritius. Col. **Reid** has laid down from 7 to 12½ miles per day, in his Chart of the Hurricane (Cyclone) of 1809, No. VIII.* My own researches certainly prove that about the part I have called the "Storm tract," (see p. 34, 35) the Hurricanes (Cyclones) are of very slow progression, being from 2¾ to 1½ miles per hour only, and upon a singularly curved track. I shall advert in the following section more fully to these nearly stationary storms.

72. In the Mosambique Channel the rate of the *Boyne's* storm (Cyclone) in 1838, is laid down as abont 10 miles per hour, though from the log of a single ship all these calculations are very uncertain.

73. In the Arabian Sea, from very scanty data, we may estimate from 4 to 16 miles per hour as the rate of progression. Our information here, however, is yet singularly deficient.

74. In the Bay of Bengal, my researches, both published and unpublished, enable me to say that the storms (Cyclones) travel at rates of from little more than 2 to 39 miles per hour, but this last very high rate has occurred only in one instance, and from 3 to 15 miles may be taken as the usual rates.

The low rate of "little more than two miles an hour" (53 miles in 24 hours) is that of the tremendous storm (Cyclone) and inundation of Burrisal and Backergunge at the mouth of the Burrampooter and Ganges in June 1822, in which upwards of 50,000 souls and vast property in houses, cattle, &c. perished. I have investigated this storm (Cyclone), and its track is that marked *f* on Chart III.

The great rise of the waters was probably owing in part to its long action over one point, and in part to its being there "a S.E. storm

* Deduced, however, from imperfect data, the fleet being much together, so that the extent of the storm circles is partly conjectured.

all day" at Burrisal, which is exactly the wind required to dam up the stream of the great estuary of the Burrampooter and Ganges.

75. In the Andaman Sea, where as before noted hurricanes (Cyclones) of terrific violence do occur, the one which has been traced travelled at the rate of about four miles an hour only.

76. Off the Coast of Ceylon the small tornado-like storms (true Cyclones) of excessive violence, alluded to at p. 38, travel perhaps at from five to ten miles an hour or more.

77. In the China Sea, from the result of all my investigations, we may safely set down the rate of progression at from seven to twenty-four miles per hour.

78. The scattered notices and single logs which we have for the Pacific Ocean, though they enable us to announce with certainty that the storms there *are* often circular (Cyclones) and of great violence, yet do not enable us to give any rate for their progression. The seaman, however, who is threatened with one will do well never to allow less than ten or twelve miles an hour, and always to risk as little as possible upon the chance of the storm (Cyclone) not overtaking him.*

79. **Stationary Storms.** As previously remarked in this chapter, there is no doubt that some storms are so slow in their progress that they may be almost considered as Stationary Storms. Every seaman has remarked of waterspouts that they often appear stationary for a time and then to move forward, and in tropical countries the same certainly occurs with the dust whirlwinds so common there, and with the sand-storms of the desert, according to Bruce's picturesque account. The same on a larger scale appears certainly to take place at the commencement of some hurricane-storms (Cyclones) in the Indian Seas. And it is not impossible that it may sometimes also occur toward their close. Those of which we have any distinct notice are the Albion's hurricane (Cyclone) of 1808, which, says

* Scudding parallel to a storm may be, and behind it *is* safe enough, but to attempt to scud "in front" of one is highly dangerous, on these very accounts, namely, because it is impossible to say what is its rate of travelling and its size.

Col. **Reid,** "seems more to have resembled the commencement of a whirlwind floating with an irregular motion, as waterspouts do in calm weather." This was in the Storm tract as I have called it, between 5° and 15° S. and 75° and 90° East; and in the hurricane (Cyclone) of November and December 1843, from Lat. 5° to 12° S. and between 82° and 90° East, investigated by me* from the logs of several ships, the actual rates of progression were found to be 60, 321 135, 47, and 57 miles in the twenty-four hours, for five days, during the whole of which it was raging most severely, and the number of the logs and position of the ships enable us to speak of this instance with much confidence.

80. In the Burrisal and Backergunge hurricane (Cyclone) track *f* on our Chart, to which I have just alluded, it appears that although it moved, as I have stated, about 53 miles in the twenty-four hours, yet I have reason to believe that for at least twelve of these hours it was really stationary, or nearly so, over the town of Burrisal. In giving these average rates of motion, we can only state what is shown from one noon to another, and in this case the 53 miles probably were accomplished mostly in the last 12 hours of the day.

81. **The sizes of Storms.** We may suppose that there might be a complete chain, as to size, of revolving storms (Cyclones); from the water-spout, which becomes a whirlwind when it reaches the land, through the Tornado of a few tens or hundreds of yards in diameter, up to the great hurricanes of the Atlantic or Indian Ocean; and so far it is certain that we cannot on the one hand say *how small* a true revolving storm (Cyclone) may be, as we have traced them to probably less than 100 miles in diameter† and possibly as small as 50‡ in the Indian seas. On the other hand, when we come to the smaller Tornado-like storms, (Cyclones) below, say, fifty miles in diameter, there is no good evidence, as yet, for their revolving invariably in the same direction when occurring in the same hemispheres,

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* Eleventh Memoir, Jour. As. Soc. vol. XIV.

† See Fourteenth Memoir, Journal Asiatic Soc. vol. XIV.

‡ Storm of the *Cashmere Merchant*, Nov. 1839, Second Memoir, Jour. As. Soc. vol. IX.

as the larger storms; and thus we cannot distinctly affirm that the very small storms (Cyclones) are subjected to the same laws, or arise from the same causes. It is one of those questions which require frequent and extensive observation to settle. For the sailor, however, it may suffice to say that rotatory storms (Cyclones) revolving according to the usual law, may be looked for of all sizes from 50 to 500 or even a thousand miles in diameter; the very large and very small ones being comparatively rare, and the small ones often sudden and severe. There is no doubt also that at times they both dilate and contract in their progress. We cannot certainly say if, when they became larger, they became more or less violent, but I am inclined to think that when they contract they sometimes augment fearfully their violence, approaching apparently the concentrated power of the Tornado or the Whirlwind. The following are instances of storms dilating and contracting, and of usual sizes in known localities.

82. In the West Indies the researches of Mr. **Redfield** and Col. **Reid** seem to show that while approaching to, or within the islands, they are sometimes as small as 100 or 150 miles in diameter; they may, and it would seem most frequently do, after reaching the Atlantic Ocean, dilate considerably, and there often attain to 600 or even 1000 miles in diameter, the wind blowing an excessively severe gale over all this area, and towards its centre becoming of true hurricane violence, and the whole vortex, so whirling, travels over thousands of miles of track.

83. In the Southern Indian Ocean, Mr. **Thom** thinks that "hurricanes when first discovered are from 400 to 600 miles in diameter." My own researches shew that they may be as small as 150, and the researches of Col. **Reid** and myself both carry them as far as to 600 miles in diameter.

84. In the Arabian sea our researches *as yet* do not warrant our supposing that storms exceed 200 miles in diameter, and indeed are perhaps often below that size.

85. In the Bay of Bengal, the usual size of the vortices is from 300 to 350 miles, but as before said,—and of this we have a very remarkable and distinct proof in the Coringa Hurricane of November 1839,

Jour. As Soc. for 1840—they sometimes contract from that to about 150 miles; augmenting, however, in violence when they do so. The remarkable storm track in the Andaman Sea was not at most more than 100 to 150 miles in diameter.

Some of the smaller sized hurricanes in the Bay also seem to move at a rapid rate and are excessively violent, resembling the Tornados on shore, which in tropical climates, and in Bengal especially, destroy literally, every thing in their progress, though their tracks are but a few hundred or a thousand yards in breadth.

86. The Typhoons (Cyclones) of the China Sea appear to vary from 60 or 80 miles to three or four degrees in diameter.

We have no sort of details which would enable us to speak of the size of the Hurricane storms (Cyclone) in any part of the Pacific Ocean.

We shall subsequently see how this question of the average size of rotatory storms (Cyclones) is of great import to the mariner.

87. **Contemporaneous, Parallel, and Dividing storms.** It is important to the seaman also to know that there are at times storms (Cyclones) which are contemporaneous (occurring at the same time) or nearly so, and these sometimes so near to each other as to travel along in parallel tracks, leaving but a very short distance between them, or to follow each other upon nearly the same track. At other times they move forward on tracks which form such angles with each other that the two storms must meet, and at others again we have instances of storms (Cyclones) starting from points nearly on the same meridian, *but in opposite hemispheres*, at 5 or 6 degrees of distance each from the equator, and pursuing each their usual tracks but revolving in opposite directions, according to the law by which they are affected! In some cases, also, storms (Cyclones) seem to be generated about the same time and in the same part of the world, but at very considerable distances from each other, and lastly there is no doubt that violent tempests (Cyclones) sometimes divide into two or more; each following a track somewhat diverging from each other. The first case of travelling on parallel tracks, or nearly so, has certainly occurred both at the head of the Bay of Bengal* and

* See Ninth Memoir, Jour. As. Soc. vol. XII.

at its mouth in the latitude of Ceylon.* In both these cases they were of small extent, but in the first of great violence.

88. The second case of hurricanes (Cyclones) following close upon each other and upon parallel tracks has also occurred in the Bay of Bengal† and in the Southern India Ocean as shewn by Mr. **Thom.** Mr. **Redfield** found that the Cuba hurricane (Cyclone) of 1844, already alluded to was preceded by another, though smaller and less violent, and he speaks of them as "the two associated storms in the Atlantic.‡ The third case of contemporaneous storms (Cyclone,) travelling on converging lines, occurred in the China Seas, when in October 1840 the Thetis of Calcutta had a Tyfoon (Cyclone) which must have travelled up from the S.S.E. to the N.N.W. at the same time that the Thetis of London, only 200 miles distant from her, had a Tyfoon (Cyclone) coming up from the W.S.W. these two tracks together making an angle of about 47°. It is supposed that the ship *Golconda* of Madras, with 300 native troops on board, must have run up to near the meeting of the two, where she foundered and all on board perished.§

89. The instance in which storms (Cyclones) have occurred on the same day, and about on the same meridian, in opposite hemispheres has occurred also in the Indian Ocean, in the storms (Cyclones) investigated by me in my Eleventh Memoir Jour. Asiat. Society, vol. XIV. In these remarkable hurricanes (Cyclones), which are traced by numerous logs from the 28th Nov. to the 3rd of Dec. 1844, two rotatory storms (Cyclones) were raging from Lat. 6° North and Lat. 7° South,‖ and in Longitude 87° to 89° East, and each, while revolving in opposite directions, was advancing on tracks diverging from each other and from the equator, along which, and on both sides of it, heavy Westerly gales only were blowing.

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* See Fourteenth Mem. Jour. As. Soc. vol. XIV.

† Ninth Memoir Jour. As. Soc. vol. XII.

‡ American Jour, Science p. 366.

§ Fourth Memoir Journal As. Soc. vol. IX.

‖ It is probable that both were formed on the 26th, but our authority for that of the Northern Hemisphere does not begin till the 28th.

90. The case of a storm (Cyclones) of great violence dividing as it were, or "throwing off" another, or several others, from itself, has been also satisfactorily shewn in our Indian researches. Col. **Reid** had already in his work admitted the probability of this, and Mr. **Thom**, who had not then seen the Indian Memoirs, thinks, p. 150, that at the formation of a hurricane (Cyclone) there may be "vast revolving discs, which in their early stages are so extensive as sometimes to include *within their central space** a number of lesser vortices." The case in which the dividing of storms (Cyclones) has been most clearly and unequivocally traced, is that of the Calcutta hurricane of June 1842, which is fully investigated in my Seventh Memoir (Jour. As. Soc. vol. XI.) In this case the hurricane (Cyclone) marked VII. on our Chart, No. III. came up from the S.S.E. appearing to have formed not very far out at Sea, or at most not farther than Lat. 20.° It was a severe rotatory gale with a pilot vessel at sea, and a furious hurricane (Cyclone) at Calcutta, driving and tearing half the ships from their river moorings, and swamping and sinking those which got adrift, with a dead calm and the shift in the middle of it. It was traced some hundreds of miles inland, by a long series of reports; and indubitably, after passing Calcutta, divided as I have delineated it into perfect circular storms (Cyclones) of smaller diameter, but of less violence. The rate of travelling of the entire hurricane (Cyclone) from sea to Calcutta was about 5·3 miles an hour, and when it had divided, the branch seems to have travelled much slower, or about at one-half of the rate of the main body.

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* Italics are mine: "within their area" is I presume meant?—H. P.

PART III.

1. The general practical application of the Law of Storms, as to avoiding Storms, Preserving vessels from damage when involved in them, and profiting by them when this can be safely done.—2. Bearing of the Centre of a Storm.—3. Wind Points and Compass Points.—4. Probability of the incurving of winds and the flattening in of Storms on approaching the land.—5. Ascertaining the track of a Storm.—6. Colonel Reid's Rule for lying to.—7. Scudding or heaving to.—8. Uses of the transparent Horn Cards.—9. Special examples for the West Indies, Atlantic Ocean, Coasts and Seas of Europe, Southern Indian Ocean, Arabian Sea, Bay of Bengal, China Sea, and Pacific Oceans.—10. Recapitulation of cases of error and of good management.—11. Cases of ships prevented by their situation on the Storm Circle from running into a hurricane.—12. Proof of the accuracy of the rules and deductions by information obtained after publication.—13. Uses of the Law, and Rules, and application of the Cards in Rivers, Harbours and open Anchorages.

91. **The general practical application of the Law of Storms.** Every sailor can understand when he looks at a waterspout or a heavy dust whirlwind, that a canoe or a Thames wherry caught in it,* however, cleverly managed and well prepared, even were she fitted as a life-boat, would run awful risks; that it would be the extreme of folly to attempt to sail *through* one, and for the boat or

* Not only in the *visible* part, but within the invisible whirl of wind which Œrsted and others suppose to exist around the part which we can discern, which last is probably only the centre, See Part V.

canoe-man not to do all in his power to keep out of its way; and finally, that if the waterspouts and whirlwinds had regular veerings of winds, and progressions on given tracks, which the boatman perfectly knew, he might generally keep out of the way of harm, and sometimes even profit by them. This is the seaman's own case. His ship is but "a cock boat," and the proudest line of battle ship "a great war-canoe," which in a waterspout or whirlwind, in the shape of a hurricane or Tyfoon, may be destroyed or damaged, or get through it safely, or profit by some parts of the wind if well managed; or the Commander of which may in his ignorance run headlong into the mischief he dreads. This is owing to the *scale* on which the operations of nature in hurricanes (Cyclones) are performed, which is so large, that to our imperfect faculties the winds always appear—and have hitherto been considered—as blowing in straight lines. The moment they are considered as curves, and probably parts of a circle or ellipse, and that this circle or ellipse is both whirling round and the whole moving bodily forward according to fixed laws, the matter is clear; but there is with many plain seamen great difficulty in understanding how to apply this knowledge, which I shall now try to remove: addressing myself to such as if we were sitting at the cabin table together.

92. It is clear that there are three kinds of cases for the management of your ship in, or at the approach of, a hurricane (Cyclone). You may avoid it altogether with sea-room and management; you may get through it safely by avoiding the dangerous centre; heaving to on the right tack; or running off in the proper direction; or you may even *profit* by it!

93. Let us take the first supposition—that of avoiding a hurricane, (Cyclone). Every seaman almost has shortened sail or altered his course, and many have hove to, to avoid a dangerous-looking waterspout. Well; this is the most usual method by which circular storms are avoided, for they are neither more nor less (for your purpose) than *wind-spouts** travelling along given tracks at certain rates, of the

* I do not mean here to agree with any of the theories mentioned p. 13 to p. 20, but am simply giving the commonest explanation in the commonest words that I can find.

neighbourhood of which the weather and your Barometer inform you; and of the course (i. e. track) of which I shall shortly shew you how to form a tolerable estimate, by the winds, your transparent Storm Cards, and your log. If that course crosses your track it is plain that you may heave to and let it pass first. If you are on that side of it that, by standing on, or standing back, for a time you increase your distance from it, or get out of its way, of course you will do so; and in both these cases you will have *avoided* a hurricane (Cyclone) by your knowledge of the Law of Storms.

94. But next: from your position, or for want of sea-room, or from the excessive suddenness of the approach of a Circular Storm* (Cyclone), you may be involved in one. Your business now is to get out of it as soon, and with as little damage, as you can.

The dangers to a vessel *in* a hurricane Storm (Cyclone) are three. The *veering* of the wind; the excessive violence of it near the centre; and the sudden calms and shifts and awful sea *at* the centre. All these involve, as you well know, damage and loss by dismasting, straining, leaks, and distress of various kinds up to foundering; and you will find in the present Chapter ample rules to show you that if involved in the Storm (Cyclone) *even with a fair wind*, you should often heave to, not to approach the centre, or with a foul one that you should, if the weather possibly admits of it, stand back; that if you have to heave to, you will, if you take the right tack, have both the veerings of the wind and the shift of it such, that you will always "come up" to it, and run no risk of being taken aback; while if hove to on the wrong one you will certainly have the wind heading you off, and in all probability be taken aback if it shifts. Of the dangers in all these cases every seaman is aware, as for instance that of getting stern-way† in a hurricane (Cyclone), and it is one, and not the least of the

* See what is said at p. 55 to p. 59, of the rates of travelling of hurricanes (Cyclones).

† Getting stern-way.—This taking aback in a tempest we all know to be most dangerous, not only on account of the getting stern-way, here mentioned, being pooped, dismasted, and the like; but from another danger, which is not sufficiently adverted to I think; and this is, that a vessel, may, in one of the terrific gusts which accompany these sudden shifts of wind, be thrown on her broadside in the trough of the sea, with her deck *towards* the sea! In such a case she is in the position of a vessel which has fallen over to seaward on a reef; and there is every chance that her hatches would be beaten in, which might swamp her. Hatches are not usually made strong enough.

practical applications of our Science, that there is scarcely yet a case on record, in all the logs that have been examined, where ships which have suffered in a circular storm (Cyclone) might not have escaped with far *less* loss if they could not have avoided the storm (Cyclone), or perhaps without any by due attention to our rules; and we can pretty nearly demonstrate also, that many which have foundered must have done so from utter ignorance of the danger they were running into!

95. The last case of which I have spoken, is that in which you may often *profit* by a hurricane (Cyclone). This is strange and startling enough, compared with the feeling of utter helplessness with which we all used in former days to regard these phœnomena, but it is all comprised in these few words. *If circumstances allow you, sail along with it or run round it, instead of sailing through it.* Go back to the consideration of the wherry or canoe with the water-spout or whirlwind, at the commencement of this chapter, and you will at once see how this *may* be true. I shall now proceed to shew you how it *is* true, and how you may *make* it true for yourself, at least in ordinary cases.

96. **Bearing of the Centre of a Storm.** Considering then every Circular Storm (Cyclone) as a great whirlwind, of which the outer part, as to strength, is a common close-reefed topsail gale, such as no seaman cares for, and no seaworthy ship is hurt by, but of which the violence increases with great rapidity as the centre is approached, till close to, or *at* it, it becomes of destructive fury.—And considering also the centre, though it may be a space from one to perhaps fifty miles in diameter, as a mere point round which the whole storm is revolving, our first care must be to find how this point bears from us; for this is what guides us in our future considerations and manœuvres.

97. This is simple enough when the Storm (Cyclone) has fairly and unequivocally commenced; I mean both as regards the state of the weather and the fall of the Barometer. The seaman should then mark off his place on his Chart, and placing that Horn Card which belongs to the hemisphere he is in, upon it, *with the wind's place over the ship's place,* he will see at a glance how the centre bears from him; thus in the Northern hemisphere with the wind at E.N.E. the centre will be seen to bear S.S.E. from the ship, if at East due South, and at E.S.E. S.S.W. of her, and so on.

In the Southern hemisphere again, a N.W. wind would give the centre bearing S.W., and a S.S.E. wind would give it bearing E.N.E. and so on successively. In a word, every wind will be a minute tangent to a circle of greater or less diameter, and for practical purposes we consider the centre bearing about at right angles to it.

98. As seamen however are not accustomed to consider the winds as tangent lines to a circle, and the bearing of the centre perpendicular to them, the consideration of "how the centre bears," even with the aid of the Storm Card, may hence sometimes be found puzzling, I add, as an assistance, the following table, which some may find it useful to glance at. The middle column relates to those at each side.

In the NORTHERN HEMISPHERE when the Wind is	The centre bears about	In the SOUTHERN HEMISPHERE when the Wind is
North.	**East.**	**South.**
N. b. E.	E. b. S.	S. b. W.
NNE.	ESE.	SSW.
NE. b. N.	SE. b. E.	SW. b. W.
NE.	**SE.**	**SW.**
NE. b. E.	SE. b. S.	SW. b. S.
ENE.	SSE.	WSW.
E. b. N.	S. b. E.	W. b. S.
East.	**South.**	**West.**
E. b. S.	S. b. W.	W. b. N.
ESE.	SSW.	WNW.
SE. b. E.	SW. b. S.	NW. b. W.
SE.	**SW.**	**NW.**
SE. b. S.	SW. b. W.	NW. b. N.
SSE.	WSW.	NNW.
S. b. E.	W. b. S.	N. b. W.
South.	**West.**	**North.**
S. b. W.	W. b. N.	N. b. E.
SSW.	NNW.	NNE.
SW. b. S.	NW. b. W.	NE. b. N.
SW.	**NW.**	**NE.**
SW. b. W.	NW. b. N.	NE. b. E.
WSW.	NNW.	ENE.
W. b. S.	N. b. W.	E. b. N.
West.	**North.**	**East.**
W. b. N.	N. b. E.	E. b. S.
WNW.	NNE.	ESE.
NW. b. W.	NE. b. N.	SE. b. E.
NW.	**NE.**	**SE.**
NW. b. N.	NE. b. E.	SE. b. S.
NNW.	ENE.	SSE.
N. b. W.	E. b. N.	S. b. E.
North.	**East.**	**South.**

99. The following is from the Nautical Magazine of December 1846, p. 651, and as we cannot have too many ways of considering the matter, to facilitate its apprehension to those who find it difficult to understand this all-important point of the bearing of the centre, I have given it here:

"We left you with the first fair wind of a hurricane, from which you were to ascertain at once the direction of the focus from you. The method we gave you was good and simple, but perhaps the following may be more so. Turn your back to the wind; then if you are in North latitude it will be on your left hand, but if you are in South latitude it will be on your right, in both cases at a right angle from the direction in which you are looking. This rule holds good, you will perceive, from the very nature of a whirlwind, in all parts of it clear of the focus. Having determined the direction of the focus from you, the next step to be taken to avoid it depends on the part of the hurricane circle on which you find yourself to be, along with the direction in which it is travelling; your principal object is to avoid the focus as you would a waterspout, and to do this you must give up the idea of keeping your course, even should the hurricane wind which you have be fair—make a fair wind of it if you like, but not to run into the focus. The *Pluto* and the *Maria Soames* did this, and both suffered for it.* Let us suppose you were on board the *Pluto* (in North latitude) when she had her first hurricane wind E. and E.S.E. Turning your back on the wind, and facing yourself W.N.W., would have given you the focus of the hurricane on your left hand, at a right angle S.S.W. of you. It would then be clear to you that standing down to the southward would be the worst course you could adopt, as it would take you into the middle of the storm, and knowing that the hurricane was travelling to the westward, as the hurricanes of the China Sea do, you would have immediately put your ship's head to the N.E. and have sacrificed a day to get out of the way of it."

100. **The Wind-Points and Compass-Points.** This subject of the bearing of the centre, leads me to remark here that the sailor will often find himself puzzled, at first, by the difference between the WIND-CIRCLE-POINTS on our Card and his Compass-points. I mean by wind-circle-points those points of his Compass *at* which he finds marked on our Horn Card, the wind which is blowing, and these are different in each Hemisphere. Thus the North wind-circle-point is at the Western Compass-point in the Northern

* The cases of these ships will be subsequently given.

Hemisphere, and at the East Compass-point in the Southern Hemisphere. The following is a table of these points arranged with the Compass-points in the middle, and the wind-circle-points on both sides, but as the word wind-circle-point is somewhat unmanageable and German-looking, and *wind.point* leads the mind to think as usual of the point *from which* the wind is blowing, I have at once adopted our word Cyclone, and headed the table on each side with the word **Cyclone Point,** so that the sailor cannot, I hope, misunderstand it.

In the Northern Hemisphere, the Cyclone Point of	Is at the Compass Point of	In the Southern Hemisphere, the Cyclone Point of
East.	**North.**	**West.**
E. b. S.	N. b. E.	W. b. N.
E.S.E.	N.N.E.	W.N.W.
S.S. b. E.	N.E. b. N.	N.W. b. W.
S.E.	N.E.	N.W.
S.E. b. S.	NE. b. E.	N.W. b. N.
S.S.E.	E.N.E.	N.N.W.
S. b. E.	E. b. N.	N. b. W.
South.	**East.**	**North.**
S. b. W.	E. b. S.	N. b. E.
S.S.W.	E.S.E.	N.N.E.
S.W. b. S.	S.E. b. E.	N.E. b. N.
S.W.	S.E.	N.E.
S.W. b. W.	S.E. b. S.	N.E. b. E.
W.S.W.	S.S.E.	E.N.E.
W. b. S.	S. b. E.	E. b. N.
West.	**South.**	**East.**
W. b. N.	S. b. W.	E. b. S.
W N.W.	S.S.W.	E.S.E.
N.W. b. W.	S.W. b S.	S.E. b. E.
N.W.	S.W.	S.E.
N W. b. N.	S.W. b. W.	S.E. b. S.
N.N.W.	W.S.W.	S.S.E.
N b. W.	W. b. S.	S. b. E.
North.	**West.**	**South.**
N. b. E.	W. b. N.	S. b. W.
N.N.E.	W.N.W.	S.S.W.
N.E. b. N.	N.W. b. W.	S.W. b. S.
N.E.	N.W.	S.W.
N.E. b. E.	N.W. b. N.	S.W. b. W.
E.N.E.	N.N.W.	W.S.W.
E. b. N.	N. b. W.	W. b. S.
East.	**North.**	**West.**

101. **Probability of the incurving of the winds in a Storm.** I should mention here that, though for convenience' sake I have spoken of the wind as blowing in a circle, and the foregoing tables

are calculated on that supposition, yet it is by no means certain that it is a *true* circle, or that even *if* the whole body of the storm be circular, the winds within it blow every where in concentric circles. Mr. **Redfield** on this subject says, in a recent memoir, (American Journal of Science and the Arts. Second Series, No. 1, p. 14,)

"When in 1830, I first attempted to establish by direct evidence the rotative character of gales or tempests, I had only to encounter the then prevailing idea of a general rectilinear movement in these winds. Hence I have deemed it sufficient to describe the rotation in general terms, not doubting that on different sides of a rotatory storm as in common rains or sluggish storms, might be found any course of wind, from the rotative to the rectilinear, together with varying conditions as regards clouds and rain.

"But I have never been able to conceive, that the wind in violent storms moves only in circles. On the contrary, a vortical movement, approaching to that which may be seen in all lesser vortices, aerial or aqueous, appears to be an essential element of their violent and long continued action, of their increased energy towards the centre or axis, and of the accompanying rain. In conformity with this view, the storm figure on my Chart of the storm of 1830, was directed to be engraved in spiral or involute lines, but this point was yielded for the convenience of the engraver.

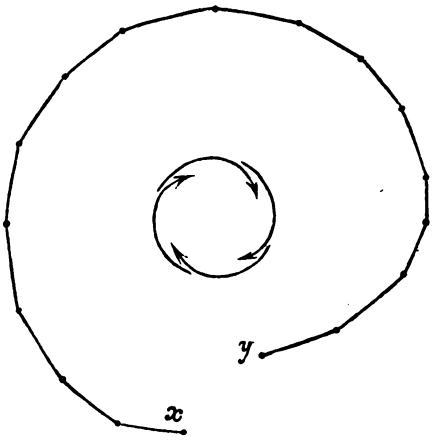
* * * * * * * *

"The common idea of rotation in circles, however, is sufficiently correct for practical purposes and for the construction of diagrams, whether for the use of mariners or for determining between a rotative and a general rectilinear wind, on one hand, or the lately alleged centripetal winds on the other. The degree of vorticular inclination in violent storms must be subject, locally, to great variations; but it is not probable that on an average of the different sides, it ever comes near to forty-five degrees from the tangent of a circle, and that such average inclination ever exceeds two points of the compass, may well be doubted."

102. And while Mr. **Redfield** was writing and publishing this in America, I was so fortunate as to be *proving* it in India, for one storm at least, that of the *Charles Heddle*, which vessel in a hurricane (Cyclone) off the Mauritius scudded round and round for five successive days! In a Memoir, the Thirteenth of my Series, published in the Journal of the Asiatic Society, Vol. XIV. p. 703, in which this storm and the *Charles Heddle's* manœuvres are analysed in close detail,* it is I think distinctly enough

* The *Charles Heddle's* log and its analysis with the Chart have been reprinted in the Nautical Magazine for 1846.

shewn that the average *resultant curve** of the winds for five days was an incurving and flattened spiral, like the figure below, in which (without reference to the storm wave) the ship may in that time have made a curved course from x to y, and we may imagine that at the centre the incurving of the winds was fully that of the arrows which I have marked there.



* I explain these terms. By the total *resultant* of the winds is meant in meteorology the calculating each separate wind during the number of hours it blows in a given time, its direction being in nautical language 'a course,' and the time or number of hours 'a distance'; the strength being always supposed the same (or this may also be used,) and all these courses and distances, (direction and time,) may make a traverse table, of which as usual one course and distance is the result. Thus, if in 24 hours we have 9 hours of N. E. and 15 of S. W. wind, the resultant is 6 of S. W. wind; or the whole atmosphere of the place may be supposed to have moved for 6 hours to the N. E., if the strength of the two winds was always equal. This is the *resultant* of the wind. If instead of the traverse table we project the directions of the wind for courses, and the hours it blew for distances, we shall have a line of some kind, which in this case is a curve, and this is the *resultant curve* of the wind. Now in the run of a vessel, scudding under bare poles, her run per hour may be supposed to be an indication of the strength of the wind, but then, the course and distance shewn by log becomes the resultant, indicating from which quarter also the resultant wind blew.

103. And I have said in reference to this result, that it appears to me not improbable that, while at some point in the whole zone of a storm (Cyclone) the wind may be blowing in a true circle, it may on the inner or central side of that part be a series of *in*curving* spirals, (spirals of vorticular inclination, Mr. **Redfield** calls them,) and that on the outer part there may be a centrifugal (i. e. a curving *off from* the centre) tendency; I have farther said, and this may not be out of place here.

"If (for the sake of hypothesis only) we admit this incurving of the winds, it follows that there may be also, not a single incurving of the same rate throughout the whole breadth of the storm, but that the incurving may be much more excessive, and amount to two or three points when the centre is nearly approached, and even be so violent at the centre as to prevent ships drifting out of it? just like the vortex of a whirlpool or a tide-eddy; which last we know will often give a boat's crew a heavy pull, or a ship much trouble, before they get out of them. Does it not seem that we have here the explanation of how some ships, as in the case of the *Runnimede* and *Briton*, in my last Memoir, may be blown and drifted round and round, without drifting out of the fatal centre, which we should look for them, nautically, to do, and which other ships there is no doubt really do. An excessive incurving of the winds towards the centre, like the wind-arrows at the centre of the figure is one, and one very likely mode of accounting for vessels remaining in this hopeless state; and moreover it may assist us in supposing how some dismal losses have occurred, whilst other ships in company have escaped. It adds also a most powerful argument, if any were wanting, for every precaution to avoid the centres—and for every one who can contribute to these researches to do so."

104. I have farther, in relation to this question, expressed a view that it may be possible that when storms (Cyclones) are increasing in diameter or dilating, the spiral is a *di*verging one, or that the arrows curve outwardly, and when it contracts (see p. 60 § 81, 85, for the contracting and dilating of storms) the spiral is a *con*verging or incurving one. We do not yet *know* this, but it is probable, or possible; and the seaman when using the foregoing table and his Stormcard should bear in mind that the wind-arrows and bearing of the centre are not strictly mathematical lines and curves, but may vary a little; though usually not so much, unless very near the centre, as greatly to affect his estimate and management.

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*"*Incurvating*" is, I know, the English-Latin word, but Incurving is a much more manageable one for sailors.

Mr. **Redfield,** we have seen, thinks it within possibility that the *in*curving* may amount to two points, or 22° near the centre, and my own views as expressed above, would require fully this. I have in the Memoir quoted, shewn how this incurving may affect our calculations of the bearing (the *exact* bearing) of the centre, and when we arrive at that part of our lessons which shew how the track of a storm may be pretty nearly calculated by the veering of the winds, we shall again allude to this subject. For all practical purposes however we may say, for example, that if in the Northern hemisphere, a gale (Cyclone) has fairly begun at E.N.E., the centre bears *about* S.S.E. from us, and we have then plenty of room and time to make even half a point, one way or the other, in the bearing, of little or no consequence.

105. I have fortunately the log of one ship in which this incurving of the wind, or what appears to me to be equivalent to it, is marked! it is that of the *Thalia,* Capt. **Biden,** Track *g* on Chart No. II., which vessel in Lat. 28° to 31° South, Long. 55° E., experienced a furious hurricane (Cyclone) from the West to the N.W. having run as long as she could carry sail to the S.W. with a heavy and increasing N.W.† gale. She then laid to at 2 A. M, on the 4th April, when her storm sails, mizen-mast, boats, wheel, compasses, &c, were in a short time carried away, rudder-head split, and other severe damage done, so that she was no doubt close to the centre. She now found the wind "*alternating 4 or 5 points, viz., from N.W. to W. b. S. and vice versa!*"

The next day, the 5th, the wind is marked as "*alternating* West to N.N.W."; on the 6th as "*alternating* N.W. to S.W."; on the 7th at 1 P. M. Nautical time, wind N.W.; 5, W.N.W.; 10, West; 5 A. M., W.S.W. the sky completely overcast, the sea one sheet of foam. On the 8th the hurricane is said to be abating, the wind being West at noon; at 9 P. M. W.N.W.; and at midnight and following morning veering to S.W., South, and South East, when the gale broke up.

During 4½ days the ship was drifted to the S.E. b. E. 248 miles, which would give a mean drift of little more than 2 miles an hour in a direct line, but she probably made twice as much distance per

* He uses the words "vorticular inclination" to express this, but I shall prefer incurving as the simplest of the two for the plain seaman.

† Her Barometer had been unfortunately destroyed by an accident.

hour, since by the alternating of the winds, she must have drifted over a succession of curves.

Since she was hove to, it is evident that she was drifting nearly with the centre, and as the gale from N.W. abated at from West to S.W. ending at South and S.E. that she drifted as it were *through* the body of the storm (Cyclone) while *it* moved slowly away from her, and that she was constantly, so to speak, during the 4th, 5th and 6th, while the wind is said to be alternating—by which I understand veering several points in an hour or two—whirled back into the more central parts of the vortex as it passed on. In the curved wind-arrows at the centre of our figure at p. 72, the arrow at the upper part exactly shows a wind, along the curve of which, if we suppose a ship to be slowly driven, this would by her drift and the motion of the vortex give her winds alternating between West and N.W. or thereabout, for we must recollect that all these data in weather of such severity are necessarily vague and imperfect. The *Thalia's* log indeed notes as follows:—

"The alternations of the wind (as noticed) were most frequent on the 5th and 6th.* The spray from the waves beating over us as thick as rain, the changes of the wind could only be correctly observed by the effect on the ship's course, or as she lay to by Compass."

We are nevertheless in this, as on so many other points, greatly indebted to Captain **Biden** for these notes, and I doubt not that intelligent seamen will now see the importance of marking correctly the veerings and oscillations of the wind, so as to furnish us with a clue to the right understanding of this deeply interesting and highly important fact in our science—the incurving of the winds towards the centre.

We have other and strong examples of this *alternating* of the winds close to or at the centre of hurricanes (Cyclones), of which I will quote but one.

In the hurricane (Cyclone) in which the *True Briton* and *Runnimede* were thrown on the Eastern Andamans, (see p. 39) the Log of the former vessel, while drifting with the vortex in a helpless state, says, "wind variable from N.E. to E.S.E.", and again "ship heading from S.E. to North, and wind blowing all round the Compass."

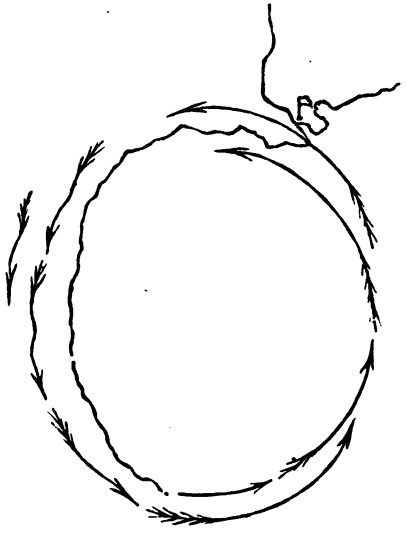
* She had run close into the centre, before broaching to and losing her mizen-mast.

106. **Mr. Thom,** p. 108, describing the Mauritius Hurricane of 1840, says,

"As the vortex approached, and the wind began to be marked by lulls "at one moment and fierce *spiral gusts** at the next, we observed several of "these (Casuarina) trees, *as if suddenly twisted round*, broken off in an instant, "and borne away for some distance on the breast of the tempest."

107. **Flattening in of the circle of a Storm when approaching high land.** Another consideration must be noted here. When the tracks of storms (Cyclones) approach the land at right angles or nearly so, and especially if there be a considerable extent of high land, it seems very probable that the vortex may be *flattened in*, as it were, and the winds thus blow, for the land side of it at least, in an oval.

In the following figure A represents a *Norte* "Norther" of the Gulf of Mexico, which we may suppose generated in the Gulf

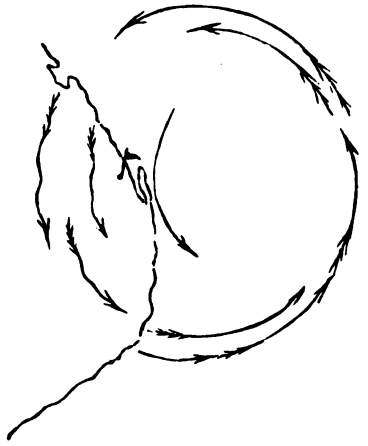


A

of Mexico or Caribbean Sea, and travelling up from the E.S.E. or S.E. till it strikes upon the shores of Texas and the Northern part of

* Italics are mine.—H. P.

Mexico, become thereby so flattened in, as to produce a much larger proportion of Northerly winds than would prevail in the same storm (Cyclone) in a wide open ocean. The figure B is an instance of the same kind where a storm (Cyclone) crossing the Bay of Bengal, in so low a Latitude as 6° and 7° North, (and this has occurred) see p. 38, strikes on the high land of Ceylon. The wavy arrows are drawn in both figures, to shew what may be (or *must* be at the surface) the effects of chains of hills or mountains, and if these cross the track of the storm at right angles still greater deviations must arise.



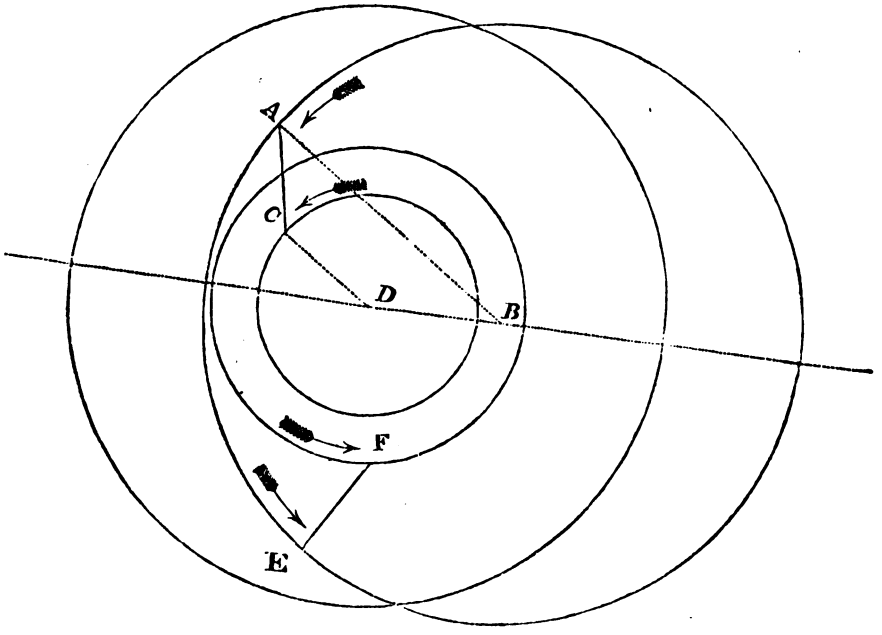
B

We do not, it should be remembered, *know* that all or any part of this takes place, but it is evidently of high probability that it does, and the seaman therefore should duly allow for it if near the land in his various considerations. We shall by and by see how this probability must not be forgotten when putting to sea from a roadstead or harbour.

108. **Ascertaining the track of a Storm.** The seaman now I presume knows how to estimate the bearing of the centre from him? and I have detailed in Part II. the usual tracks of storms, and at p. 6, the law of their revolution, as laid down by Mr. **Redfield,** and now so amply demonstrated for both hemispheres; but as there are still great tracts of the globe, though much frequented by shipping, in which we are ignorant of what may be the tracks of storms (Cyclones), it may be as well to give here the method by which a careful Commander may, approximately at least, estimate what is the track of an approaching storm (Cyclone), or of one towards which he thinks he is running. He will find it useful to do this, not only in parts where the tracks of storms (Cyclones) are unknown, but also where they are pretty well ascertained. He should always, in a word, look on the centre of the hurricane as a privateer, or a pirate, or an enemy of superior force, and make his calculations for avoiding its neighbourhood. He must not forget, that if he has *his* course and drift, the storm has also a course of *its* own, and brings with it currents, see p. 9, (often strong ones,) to both of which he must attend. Recollecting this, he may now farther use his storm card, with his log, to judge how the storm itself is travelling, in the following manner.

If it be supposed that the hurricane (Cyclone) is travelling from the S.E. to the N.W., it will be seen that, supposing the ship in any part of the circle, this will give different changes of the wind to what would occur if it were travelling, say from E.N.E. to the W.S.W. An allowance being made for the ship's track between any two changes of wind, he will find that the line between the two points occupied by the centre of the circle, will lie in a direction which is *nearly* that of the track of the storm; and that in all which follows, he will only do what he does when sailing in fine weather along shores of which he has no exact chart: he takes the bearing of two head-lands, guesses their distance, and from his run lays down the trending of the coast.

109. The track is estimated by projection, as in the diagram below.



Scale 100′ *to an Inch.*

Draw a small line through the ship's place at A in the direction of the wind, which we will call N.E., and another A B, from the same point, perpendicular to it, or S.E., which represents about the bearing of the centre of the storm (Cyclone) from the ship, at that time, in the Northern Hemisphere. We can only *guess* at the distance, which we do by estimating it from the violence of the wind, the rapidity of

its changes, and the fall of the barometer.* I should say, that for a strong gale, which would allow a good merchant ship to carry her close-reefed topsails and foresail, we might allow 200 miles. For a hard gale, in which the foresail could scarcely be borne, 150 or 100 miles, and for a very severe gale, a still shorter distance. The veering of the wind, the increase of its force, and the fall of the barometer, are of course more rapid the nearer you are to the centre, and some storms are also more violent and travel faster than others.

Let us then put down 150 miles on this S. E. line, or from A to B., for our present distance from the centre of the tempest, (Cyclone) and in six hours afterwards let us suppose the ship to have made 54 miles on a South course, bringing her to C, and that the wind is increasing fast, but is still at N. E., with the barometer falling, and every other appearance of bad weather.

Mark off this run of 54′ on a South line, and as the wind is still at N. E., draw a S. E. line as before, which points again towards the centre. We have to consider now that we are probably nearer to it than before, for we know that *it* also, in these six hours, has been travelling to the Westward between 8 and 16 miles at the least, and the barometer has continued to fall and the squalls are much more violent and frequent. Taking 12 miles an hour, or 72 miles for the six hours in the compasses, we find that this distance from B will strike upon the S.E. line (which is the perpendicular to the wind's course, and now the bearing of the centre) at D, which we may thus take to be the new place of the centre. This, it will be seen, gives the storm (Cyclone) a W.N.W. course, which is a likely one, and places the ship now at only 58 miles from its centre. It is clear, therefore, that we are thus running in upon it, and though our distances

* I trust that the day is not distant when we may make the fall of the Barometer in a given time, a *measure* of the distance of the centre of a storm from us, but I have not yet time to follow out my views on this head. Mr. **Thom** has taken up this question, and I shall advert to it in **Part V.**

are mere guesses, they are, for the Bay of Bengal and the China, or Caribbean Sea, *very strong probabilities*, because of the continued fall of the barometer, and the great mass of evidence which exists to prove, that at certain seasons almost all their violent storms are turning gales, (Cyclones) and move from the Eastward to the Westward.

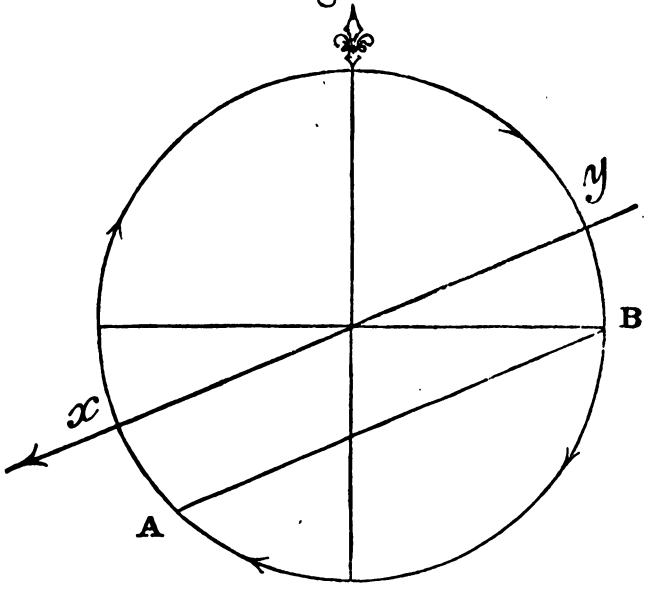
I have placed on the Southern half of the Diagram a case wherein another ship, E, in the same tempest, at the same time, but at a distance of 220 miles from the ship at A, may have the wind at N. W. first, and steering N.E. 54 miles, to F, bring the wind to West, because the centre of the hurricane, (Cyclone) travelling as we suppose, bears then about 82 miles North from her. From evidence published in my Fourth Memoir, Jour. As. Soc. Vol. IX, there seems little doubt that the unfortunate ship *Golconda*, which foundered with 300 Madras troops on board, must have run from the south side of a hurricane into its centre, in the hurricanes (Cyclones) of 22nd to 24th September 1840 in the China Sea, as I have supposed this vessel to be doing. See p. 62, § 89.

110. Again: we may suppose, off the coast of North America, a ship in Lat. 40° North with a storm (Cyclone) evidently setting in at S.E.b.S., and that in a run of 6 hours at 10 miles per hour, or 60 miles to the W.N.W. the wind has only veered two points and become S.E. b. E., but has increased in strength very considerably and rapidly, and with a falling barometer. The projection of this will give us a storm (Cyclone) coming up from the S. Westward, as usual thereabouts, and we are thus right in its track. As it may in such a case be impossible or dangerous to scud on account of sea and wind, and the dread of the dangerous shift, we have in such a case to consider *what will be the proper tack to lie to on?* which will be shewn in the next section.

111. The track of a storm (Cyclone) may be judged of also from the shift, though some seamen may be embarrassed in considering accounts of storms by others, or from their own logs, to judge what *was* the track of the storm from the shift of the wind at the centre, but nothing is

more simple. It may be done by the eye with the Horn Card, and a little attention to the table of Cyclone-points at p. 70; but if exactness is required, it should be done by projection. Thus, I suppose, in the Southern hemisphere, that a ship, lying to, has the shift from S. E. to North, See Fig. I.

Fig. 1



Strike any circle, cross it with diameters, and mark on it the S.E. Cyclone or *wind-point* (see p. 70,) of the Storm card for that hemisphere, which will be on the lower part of the left hand side, at A; then mark the North *Cyclone point* which will be where the diameter to the right touches the circumference at B; join these two, and draw a parallel *x,y.* through the centre of the circle. Measure off the angle B. *y*, or its complement from the fleur de lis to *y*, and it will give the compass track; which in this case is *from* E.N.E. to W.S.W. or from *y* to *x*, because the shift being *from* the S.E. to the North, the storm (Cyclone) must have been moving to the left, or from B to A to strike the ship first at A.

Again: suppose in the Northern Atlantic a shift from S.E.b.E. to N.b.W. (see Fig. II.)

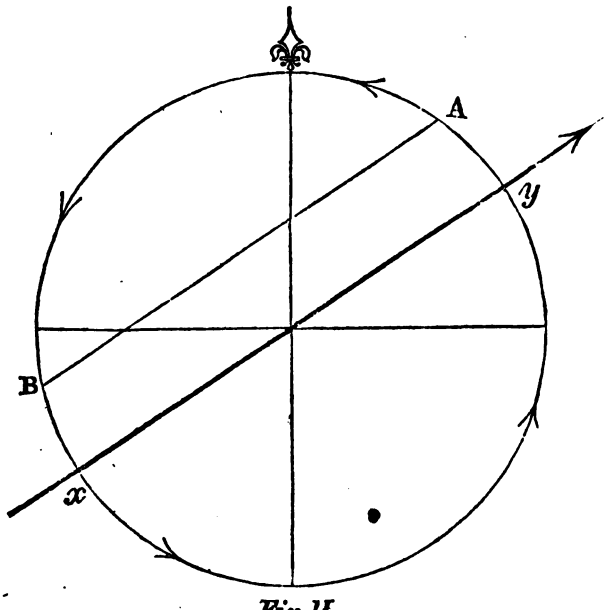


Fig. II

Here, as before, A is the *Cyclone point* of S.E.b.E. (or compass N.E.b.N,) in the Northern hemisphere, and B of N.b.W. (or compass W.b.S.). Join them, and draw the parallel *x y* through the centre of your circle, and the angle between the *fleur de lis* and *y* is the compass rhumb of the storm's (Cyclone's) track; and as the wind, this time, was at first blowing from the S.E.b.E. you see the hurricane (Cyclone) must have been *travelling up* from the left hand or from B up to A, or on a track of *from* the S. 55° West to the N, 55° E. or from *x* to *y*. I need not add that the seaman in these essays must of course take the average direction of his winds when the hurricane (Cyclone) is at full strength, before and after the shift. He will also understand how, without any sudden shift, when the wind has only *veered* rapidly with him, so as from any

one point to settle for some hours at another, it was travelling on a given track, and he was to the North or South of the centre, though no distinct calm interval occurred, which is often the case.

112. It may appear at first sight to the old seaman, as well as to the novice and landsman, that we are a little hasty in deducing our opinions of the track from the shift of wind; but I am fortunately enabled to shew that in one instance, certainly, where the shifts have no doubt been most accurately marked, the track is perfectly defined by the various shifts of wind of three ships exposed to the same hurricane (Cyclone) in sight of each other, but in different parts of the same calm centre!

This remarkable and highly interesting fact I derive from a series of logs sent out to me by the Honorable the Court of Directors of the E. I. Company, which contains amongst others, the logs of the Fleet under convoy of H. M. Sloop *Swift*, homeward bound from China, in the Northern Pacific Ocean in July 1797. In this Fleet, as quoted by Mr. **Redfield**, from Lynn's Star Tables, the H. C. S. *Buccleugh* was in severe distress, and the *Swift* foundered* in the second of the hurricanes (Cyclones) which they encountered on the 2nd July (track *a* on the Chart.) In the third of these, at noon on the 8th of July, the H. C. Ships *Cuffnells*, *Duke of Buccleugh* and *Taunton Castle* were in company and in sight of each other, in a tyfoon (Cyclone) from the N. Eastward, when a lull took place, and at 2 P. M. a shift of wind, which I give below as in the three logs before me, and I note how such a shift for each single ship would give the track of the hurricane (Cyclone).

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* And we can not only almost mark the exact spot where she did so, but we can say now *to a certainty* by what error (want of this our new knowledge) these brave hearts were lost to their country! The whole fleet were scudding across the S. Western quadrant of a slow moving, or stationary, storm (Cyclone) under square sails (foresail, &c.), and the *Swift* was nearest to the centre. The Indiamen mostly broached to and lost topmasts, rudders, lower masts, &c. &c. The *Swift* was never more heard of, and melancholy to relate, she had on board the crew of H. M. S. *Providence*, wrecked on a coral reef some time before, so that altogether she is supposed to have gone down with nearly 400 souls on board!

Ship.	Wind at Noon.	Shifted at about 2 P. M. after a lull to	Shewing a track to the
Cuffnells.	N.E.	W. b. N. Veering rapidly to S.S.E.	W. b. N.
Buccleugh.	North.	S.W.	W.N.W.
Taunton Castle.	N.N.E.	S.S.W.	W.N.W.

113. If the young mariner desires a lesson for practice, this is a capital one. He should strike a circle to represent the vortex of the hurricane (Cyclone) say of 15 or 20 miles diameter on any scale. Then marking *Cuffnells* at the N.W. *compass*, (which is the N.E. *Cyclone*) point on one side; and at the E.N.E. compass, which is the S.S.E. *Cyclone* point (see page 70,) and so on of the rest, and drawing the parallels as just described, he will have before him at once the proof of how truly the tale of the track would have been told by each separate ship (to be between W.b.N. and W.N.W. accurately) in spite of their different changes, and how nearly we may rely upon a well kept log to indicate it.* The apparent anomaly of the *Cuffnells'* log is rather a confirmation, since it shews, either, that there were, what we have just described, irregular gusts at the centre, or that she had drifted for a time into the Southern part of the circle. He will farther observe in the table of references to our Chart No. IV. that the Fleet was to the Northward of these three ships, and the track (*b*) is confirmed by the evidence of their logs to have been about North 65° West, on the average of *three* days from the 8th to the 11th or 12th. And I may add, that in more than one instance where we have deduced the tracks from the shift of wind experienced by a single ship, subsequent information has shown us to be perfectly correct.

114. Col. **Reid's Rule for the proper tack to lie to on.** This is one of those great, but simple, results for which every seaman owes to this distinguished officer a deep debt of gratitude; and every year and every new investigation proves the utility and beauty of the rule. I have already explained that the track or course of a storm is considered like that of a river, and that looking to the mouth of the river, we call the banks of the river right and left

* And the logs of the East India Company's ships were in no respect inferior to the best of those in the Royal Navy.

banks, according as they then lie; so looking *to* the quarter *towards which* the storm (Cyclone) is moving, we call the right side of the storm all that half of the supposed circle, or ellipse, on our right hand, and the left side all that on our left. I cannot do better here for my reader than to extract nearly what Col. Reid has said at p. 530 of the second edition of his work.

'*Rules for laying Ships to in Hurricanes.*—That tack on which a ship should be laid to in a hurricane has hitherto been a problem to be solved; and is one which seamen have long considered important to have explained.

'In these tempests, when a vessel is lying to and the wind veers by the ship's head, she is in danger of getting stern-way, even when no sail is set; for in a hurricane, the wind's force upon the ship's masts and yards alone will produce this effect, should the wind veer ahead, and it is supposed that vessels have often foundered from this cause.

'When the wind veers aft as it is called, or by the stern, this danger is avoided, and a ship then comes up to the wind instead of having to break off from it.

'If great storms obey fixed laws, and the explanation given of them in this work be the true one, then the rule for laying a ship to, follows like the corollary to a problem already solved. In order to define the two sides of a storm, that side will be called the right hand semicircle, which is on the right of the ship's course, as we look in the direction in which it is moving, just as we speak of the right bank of a river. The rule for laying a ship to, will be, *when in the right hand semicircle, to heave to on the starboard tack, and when in the left-hand semicircle, on the port tack in both hemispheres.*'

'The first of the two figures inserted here is intended to represent one of the West India hurricanes moving from the S.E.b.S. to the N.W.b.N. in the direction of the great arrow drawn across it. The commander of a ship can ascertain what part of a circular storm he is falling into by observing how the wind begins to veer. Thus, in the figure, the ship which falls into the right hand semicircle, would receive the wind at first about E.b.N., but it would soon veer to East as the storm passed onward, and supposing her lying to. The ship which falls into the left hand half of the storm would receive the wind at first at N.E., but with this latter ship instead of veering towards East, it would veer towards North.

Proper North, and Wind East.

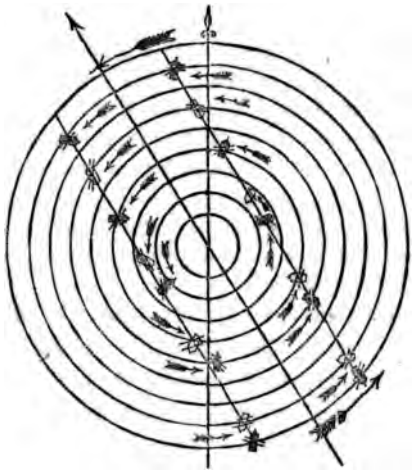


Figure for the Northern hemisphere.

Ship on Starboard Tack.

Proper East, and Wind South.

Proper West, and Wind North.

Ship on Larboard Tack.

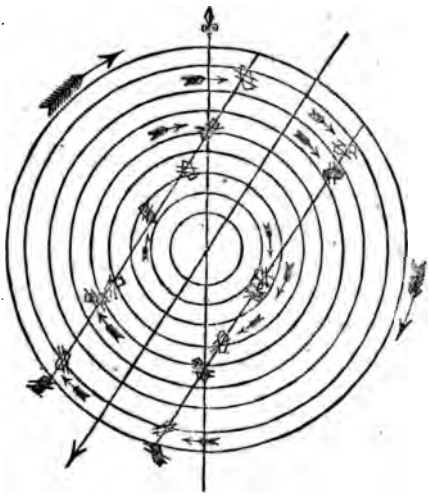
Proper South, and Wind West.

Proper North, and Wind West.

Figure for the Southern hemisphere.

Ship on Starboard Tack.

Proper West, and Wind South.



Proper East, and Wind North.

Ship on Larboard Tack.

Proper South, and Wind East.

'The explanation of the rule will best be made out by attentively inspecting the two figures. In both, *the black ships are on the proper tacks*; the white ships being on the wrong ones.

'The second figure is intended to represent one of those hurricanes in South latitude which pass near Mauritius, proceeding to the South-westward. The whirlwind is supposed to be passing over the vessels in the direction of the spear head. It will be seen that the black ships are always coming up, and the white ships always breaking off; and that they are on opposite tacks, on opposite sides of the circles.

'If hurricanes were to move in the opposite course to that which they have hitherto been found to follow, then would the rule be reversed, for the white ships would come up, and the black ships break off.'*

115. The ever memorable loss of the prizes taken by **Rodney** on the 1st of April 1782, together with an immense number of merchantmen, and nearly all the men-of-war convoying the fleet, should not be passed over here, as affording a truly awful lesson of the importance of our science. From Mr. **Redfield's** "Memoir" in the United States' Naval Magazine, and a Memoir of Admiral **Graves**, before me, which I think has been copied from the U. S. Journal, it appears that H. M. S. *Ramillies*, *Canada* and *Centaur*, of 74 guns each, with the *Pallas* Frigate, and the *Ville de Paris* of 110 guns, *Glorieux* and *Hector* of 74, *Ardent* and *Caton* of 64 guns each prizes, and a convoy which, even after those for New York had separated and the *Ardent*, *Pallas* and *Hector* put back, still amounted to ninety-two or ninety-three sail, were overtaken by a hurricane (Cyclone), on the 16th of September 1782, which increased rapidly from E.S.E. The fleet fully prepared for bad weather, hove to, but unfortunately on the starboard *(which was the wrong)* tack, for at 2 A. M. on the 17th, when in about Lat. $42\frac{1}{2}^{b}$ North, Long. $48\frac{1}{3}°$ West, the whole fleet were taken aback by a shift of wind, evidently of terrific violence, to N.N.W.† The *Ramillies*, Admiral **Graves'** flag-ship, lost her main, mizen, and fore-top-masts, was pooped, and apparently in danger of going down stern foremost; and the following day shewed that many of the men-of-war and of the merchantmen also had been

* I have already (p. 78,) explained that the application of the law depends entirely on the knowledge of the track, and this, as here stated, he will constantly see exemplified.

† Observe that is nearly our Fig. II, at p. 83.

as ill treated, for there were "signals of distress everywhere." The gale (Cyclone) continued at N. W., and before it left the helpless fleet, the whole of the men-of-war, except the *Canada*, had foundered or were abandoned and destroyed; and so large a proportion of the merchantmen, that this is supposed to be the greatest naval disaster we have upon record. Upwards of three thousand seamen alone are computed to have perished by it!

The track of the storm (Cyclone) appears from the shift, E.S.E. to N.W.* to have been one travelling to the N.E. b. N. about five degrees to the Eastward of the termination of Track B on Chart I., and though it is true the men-of-war, as well as the prizes, were in a deplorable state, yet no doubt, the tremendous shocks and consequences of dismasting, pooping, and the like, added no little to their danger; for it is said of the *Centaur*, that the Admiral was thrown out of his cot by the shock! If, with the wind at E.S.E., sail had been carried to the North but some fifty or a hundred miles, the centre would have passed by without reaching them, and heaving to on the *larboard* tack, for they were on the *left* side of the track, would have then given them a common gale, drawing aft till it ended with one at W.N.W. or a fair wind. The young sailor should make another lesson of this.

116. **Scudding or heaving to.** Every seaman of course begins by considering this question with reference to his sea-room. In what follows, I shall suppose throughout that he *has* sea-room, and that, either because he has a fair wind in the tempest (Cyclone), or because he wants to profit by it, or wants to get out of its way, or has a leaky or crank ship, making lying to dangerous, he desires to scud, or wishes to know what he had better do. He has also of course by this time a correct notion of how the centre of the storm (Cyclone) bears from him, and for many parts of the world what are the usual tracks, or he has calculated pretty nearly what the track of the one he is engaged in is, from his previous run and the veering of the wind, as shewn at p. 79. He has now to consider if he is, with relation to these *two* data, the bearing of the centre of the storm and its track ——

* The first squall mentioned as from N.N.W. I take to have been an incurving wind at the centre, and that these are the average points.

A. *Behind* it.

B. *On either side of it, at about right angles* to its track.

C. *Before* its track.

Now (A.) his precautions must be directed if *behind* the storm,

*In scudding,**

(1.) Not to run into the heart of it.

(2.) Not to run too far *before* and then gradually across it.

(3.) Not to lose the advantages he may derive from it.

In heaving to,

(1.) To do so on the right tack.

(2.) To be careful when bearing up not to overtake it again; and therefore ——

(3.) Not to bear up too soon.

Or (B.) his precautions if *on one side* of a storm, at about a right angle to its track must be,

In scudding,

(1.) To scud *with* it, but not to edge too far into it—i. e. to keep at a safe distance from the centre.

(2.) Not to over-run it, and be thus led to cross into, and before it.

In heaving to, to do so on the right tack.

And (C.) his precautions when *before* the track of the storm must be in this, which is the most difficult case, for it is that of a storm "coming down" upon him (see p. 58.)

In scudding,

(1.) To be careful that he can do so in a direction which will take him out of the way of the centre.

(2.) That he has full *time* (allowing always at least from fifteen to twenty miles an hour for the storm's (Cyclone's) rate of travelling, to get out of the way of the centre.

(3.) That if already in part, as it were, out of the way of the focus (i. e. when there is every probability that it will pass *near* but not over him) he does not, by scudding, put himself more fully in the way of it.

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* Sailors will note that I use the word scudding in this paragraph, and indeed elsewhere rather loosely, and sometimes almost improperly, as nothing but sailing with the wind right aft, or two or three points on the quarter, should in strictness be called scudding, but for shortness sake I have not been particular.

(4.) To see if, by hauling up (should wind and sea, and the condition and qualities of his ship allow of this,) and *then* heaving to when the hurricane (Cyclone) by approaching becomes of full strength, he cannot get farther towards its border, and thus more surely at a distance from the dangerous central focus.

In heaving to,

(1.) To heave to on the right tack for the shift and for "coming up" to the wind as it changes, instead of breaking off.

(2.) When the calm centre reaches the ship to keep the vessel's head the right way to avoid being taken aback.

117. The mariner (I mean the careful man who conscientiously endeavours to do his duty to his country or his owners) will easily see how simple it is, first to ascertain his position with respect to the bearing of the centre, and then which of these lines of management it will be best for him to adopt; and he will no more consider the time as lost in these brief calculations than he would that which at the approach of a dark stormy night, near a dangerous passage, he devotes to weighing carefully whether it will be better to stand on, or to heave to, or work to windward, or anchor.

118. I desire to be understood by those who may read and consider all this, and indeed for the whole of this work, that I quite appreciate, and fully allow for, the differences between the smart and well-found man-of-war, with her well disciplined and numerous crew, and her tried and trained officers, and the ill found, half-manned merchantman, with (I grieve to say) too often grossly insubordinate, or incapable officers and ship's company: and I am well aware how safely the commander of the first can calculate upon his officers, his men and his ship, to the hour and the minute, and how little the last can venture upon the chance that in two or three hours he may have far worse, or better, weather; but writing for all, I explain as clearly as I can the danger and the prudent course, and each must calculate for himself what his ship, his officers and his crew can bear and do in the hour of need, if it comes.

119. **The use of the Transparent Horn Cards.** To explain this, I suppose I have to shew them for the first time to a plain Seaman, or to a very young Officer who knows nothing about

them, and by following with a little patience the steps laid down in the following lessons, there are none who will not, I trust, be able quickly, not only to understand it themselves, but to explain it to others.

The first and most useful lesson the plain seaman can give himself in this new science is, to obtain the habit of considering that all winds *may* be, and many certainly are, *not blowing in straight lines, but in curves.* This is not so easy; for we are all habituated from our childhood to consider the wind both as blowing "where it listeth" and also in a straight line from one point to another*, so that we are a little puzzled when we must think of the (apparently) straight line shown by our dog-vanes and weather-cocks, or by the trim of the sails of a whole fleet, or the furious gusts of a squall or hurricane, as only part of a great curve.

The best way to form a good notion of this is to take a common map of any kind, on a large scale, say on that projection on which the parallels of latitude are great curves, and put a dot on one of the parallels for your ship's place. Now, putting the hands, or two pieces of paper, so as to cover a parallel of latitude all but an inch, or half an inch, on each side of your dot-ship you will readily see then how the folks on board of her might suppose and affirm *their* wind to be a straight line, just as you do at sea of *your* wind; and yet you can see that it is part of a great curve which *might* be also part of a circle of several hundred miles in diameter. It is indeed supposed by Professor **Dove** and Mr. **Redfield** that *all* winds form circuits, which would make them all curve in some part, if not in the whole of their courses.†

* Just as we talk of the *level* of the sea, many landsmen using the word as if it applied to a horizontal and not a curved surface of about eight inches to a mile.

† If we suppose a storm of 300 miles in diameter and thus (in round numbers) a little more than 900 miles in circumference, and 32 ships placed round this circumference, each with a wind one point different from its neighbour, they would still be 29 miles apart. Many of the gradual changes of the wind from quarterly to a-beam, close-hauled, and breaking off from the course, are probably owing to these circuital winds as the ship runs on, though in fine weather. There is no doubt that in tropical countries the wind is often blowing in circular vortices, though not rising to the force of a storm.

The next lesson to give one-self is this. When you have obtained the habit of recollecting that the wind, though apparently blowing in a straight line for you, is, or may be, really blowing in a curve forming part of a circle or ellipse, to consider then *on what part of the circle* or ellipse you are? Say the wind is at North; you may suppose according to the hemisphere you are in, that you are on the East or the West side of a circle; and so on of every other wind, as in the tables given in pages 68 and 70.

Making marks for ships' positions on a sheet of paper or an old Chart, and putting the Transparent Card over them so as to see by it *how the centre bears* from the ship is the next lesson, and will be found highly useful, for it is not every seaman who has the habit of considering his present wind a minute tangent line only, and the centre of a storm lying, according to the hemisphere he is in, at a perpendicular from that tangent. The *habit* of thus considering the wind, is what will give the plain seaman a complete understanding of the theory. He can always refer to the table in p. 68 to see if he is correct, and he will find it to be a sort of "boxing the compass at right angles," which every one has not got.

The next lesson is to move the Storm Cards, each in their own hemisphere—for with them *you have the hurricane in your hand,* recollect—over an Island, or a fixed mark of any sort to represent a ship lying to, on a Chart, and to notice how the effect of a vortex of any size, if so moving, would produce the changes of wind, of which we read; supposing always that we move the Storm Card along the right *track*:* As across the Leeward Islands from the SE.; along the Coast of North America from the SSW. or SW.; in the China Seas, from between NE. and SE. to the SW. and NW., &c. for, as will be easily seen, *if the track of the Storm varies, the changes of the wind also vary,* and if in either hemisphere a storm came, for

* The seaman will find it convenient to have two bullets flattened and covered with silk and a piece of narrow red tape about 18 inches long, stitched to the inner side of each; these may be laid down in any direction on a Chart, and will represent the track of the focus of a storm very distinctly as sort of a "Line of mischief" over which the Card may be conveniently moved at pleasure, and the changes perfectly noted.

instance, from the West instead of the East, the changes would be exactly opposite.*

The seaman should next mark off a ship's place, real or supposed, with her run or drift for any given number of hours, and then, moving up the Storm Card near, or across this, observe how the motion of the Storm *and* this run or drift induce different or more rapid changes of the wind, or take a ship out of, or run her headlong into a Storm. These preliminary lessons may appear trivial, but they are not so; and the seaman who will give them a little attention, will find great advantage from so doing. I need, I hope, remind none that when bad weather is coming on they will have other matters to attend to than studying *then* the applications of the Science; and that it is the cool and patient consideration of such things in fine weather and at leisure, that makes the able and ready seaman when a crisis arrives.

120, I now proceed to apply all this by practical lessons in various parts of the world for the uses of the Storm Cards on horn, which will be found in the pockets of the covers; one being for the Northern, the other for the Southern hemisphere.

The following rules must be borne in mind:—

1.—The card may be supposed to represent any sized storm from 20 to 500 miles in diameter, and as many more circles may be supposed to be added to it as may be necessary to suit the scale of the chart.

2.—The *fleur de lis* must always be kept on the *magnetic* meridian when using it.

3.—It is always to be placed so, that the *wind's place* is over the *ship's place*.

4.—It is to be moved as required along the known, or estimated, track of the storm.

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* He should next mark off *two* ships' places, and move his Storm Card so as to pass the centre between them, noting how the wind will *veer* with each ship, though the whole hurricane is *turning* according to the Law of its hemisphere. If he sets these down on a piece of paper he will see at once how the contradictory accounts of winds veering and "backing round," as it is called, are perfectly true, though till now inexplicable. See Diagram at p. 11.

121. **Special examples for the use of the Storm Cards.** *a.* FOR THE WEST INDIES.—Mark off the place of a ship in Lat. 16° North, Long. 50° West, and suppose her bound to Trinidad.

The weather and barometer indicate the approach of a hurricane or severe gale, and the wind is at EbN.

Now place the Card so that part of the outer circle which lies between East and E.N.E. may lie over the ship's place, and it will be seen that if this is a hurricane* (Cyclone) the centre of it bears SbE. *or thereabouts* from you.†

Next you know (see p. 25 and chart I.) that it is hereabouts that the West Indian, Atlantic and American coast storms seem to take their rise, and that they travel from hence, as far as yet known, on a track to the Northward of West, but rarely so far so as Northwest. W.bN. or W.N.W. then is probably about its track, and fifteen or eighteen miles its rate of *sailing* in that direction.

I suppose your sea to be not yet *very* heavy, so that with the wind at E. b N. and every chance of its becoming more Northerly, your ship sound, and crew hardy and smart, with plenty of good helmsmen amongst them, the temptation to run on is very great; but you see also in a moment that, if you do, you will cross before, within, or close behind, or at the very centre of the hurricane (Cyclone), and that you will thus, as it were, thrust yourself, if not into the jaws of destruction, certainly into a useless peril.‡ Now as no man runs his ship headlong into a waterspout when backing his main-yard for ten minutes can keep him out of it, your prudent course is to lie to, and allow the storm (Cyclone) to travel past you, and the rise of your barometer and the gradual veering of the wind to the Southward of East will show you that it has done so, and all

* The fall of the Barometer and the appearance of the weather are in all common cases sufficient to distinguish it from the trade rising to the strength of a gale, as trade winds and monsoons sometimes do.

† *Thereabouts*, because there may be some irregularity or incurving of the wind; see p. 74 § 104.

‡ You will see also that supposing even that you get safely through or past the centre by "dashing at" the hurricane, all you gain on one side of the storm circle you lose on the other, as the winds become Westerly!

you have then to be careful of is, when standing on not to *overtake* the storm, should it by any chance be a slow moving one: see p. 90, for your various considerations and chances.*

122. Suppose your ship in 16° North and 72° West with all appearances of a hurricane, (Cyclone) the wind at W.N.W. and she is bound to Grenada. Mark off her place, and lay the *W.N.W.* of the Horn Card over it; and you see at once that this is a storm of which the centre lies about N.N.E. from you, i. e. between you and the shores of St. Domingo, which it is probably then ravaging; and you moreover see that, for you, it is a fair wind by which you may safely and surely profit; hauling first a little to the Southward to be sure of a good offing from the more violent and dangerous part, and also to get room to keep away a little, if the sea should be heavy when you get on the S. Eastern quadrant of the gale (Cyclone) when the wind, as you see, will haul to the S.W.

123. Suppose you are bound from New Orleans to the Havannah, and that at a day's sail from the first port you begin to have a falling Barometer, a heavy sea, squalls, gloomy weather, &c. and "half a gale" from E.N.E.

With the old knowledge we should all, certainly, "carry on" to this, and keeping the wind about a point before the beam, push on for our port under double reefs, with a close look out on the steerage? But place the Storm Card on the chart, and you will see that if you do so, you will be rapidly plunging into the hurricane.

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* It requires, indeed, some little confidence in this kind of knowledge for a Commander to bring himself to what is called "throwing away a fair wind;" and more than one has told me, after being severely damaged, that though they suspected from the Law of Storms, that they were running into mischief, yet they could not resolve to lose a chance where others might push on and laugh at them; and many, like myself, may have heard between 30 and 40 years ago, "the Captain's *Barometer-gales of wind*" grumbled over, when reefing top-sails by its warning, and even his Lunars and Chronometers sneered at! It seems that, with seamen especially, all useful knowledge has to force its way through this dislike of novelties. One would give something to know what the good old, first rate observers with the Astrolabe and Quarter Staff and Davis' Quadrant, said of the "looking glass gimcrack" which we call Hadley's Quadrant?

But you need not therefore heave to, for you will note that the hurricanes hereabouts all travel between the E.N.E. or N. Easterly to North and even N. Westerly. It is clear then that you *can profit by it by sailing round it*, i. e. keeping away West, W.S.W., S.W., S.S.W., and South as your Barometer guides you, and thus make a curve round the heel of the storm, and which will not be a large one; for as *it* is probably flying ten or twenty miles an hour on *its* track while you are, in the beginning of the storm and if the track be one to the Eastward of the meridian, going wholly the other way, the wind will veer at first so rapidly, if the track is to the Eastward of the meridian, that you will be surprised to find how soon your Easterly gale is at North, N. W. and West, just as your Storm Card shows. If however it should be one of the hurricanes (Cyclones) which like M L or E have tracks to the Westward of the meridian, it is evident, that this may be merely scudding *with* the storm, if its track is very Westerly, or crossing the track before the centre, and perhaps much too near for safety. This will be quickly known by the veering or steadiness of the wind (see p. 79) and if it is supposed that the track *is* one of these, the plan is to heave to on the starboard tack, being in the right hand semicircle.

124. **In the Northern Atlantic.** A ship from Boston bound to Bermuda at 200 miles S.E. of Cape Cod, meeting a N. Easterly gale with a falling Barometer and other indications of a hurricane (Cyclone) will clearly understand also, why she has her choice of running into the heart of the storm (Cyclone), at the risk of being dismasted or upset, if she persists on her direct course as long as she can stand on, or of sailing round the Western edge of it, and thus at the expence of a little curve in her track making a fair wind for her whole voyage.

125. Colonel **Reid** has given in his work the following: which I copy entire, as affording the seaman both for that and other quarters of the globe an able instance of how we may in time profit by this enlarged view of the practical utility of the rules of our new science. Every reflecting and experienced seaman must recollect his disappointments (and often his losses, at least of time if not of money) at finding his fair wind gradually become a foul one, and not a few

may recollect by how many theories and assumptions they have endeavoured to account for these apparently capricious veerings.

A NOTE.

On the Winds, as influencing the tracks sailed by Bermuda Vessels; and on the advantage which may be derived from sailing on Curved Courses when meeting with Progressive Revolving Winds.

"In high latitudes the prevailing atmospheric currents, when undisturbed, are westerly, particularly in the winter season. As storms and gales revolve by a fixed law, and we are able by observation to distinguish revolving gales from steady-blowing winds, voyages may be shortened by taking advantage of them.

"The indications of a Progressive Revolving Gale, are, a descending barometer with a regularly veering wind, or with the wind changing suddenly to the opposite point.

"In the Northern hemisphere Storms revolve from right to left, thus,

"In the Southern hemisphere Storms revolve from left to right, thus,

"The indication of a steady-blowing wind which will not revolve, but blow in a straight-line direction, is a high barometer remaining stationary. When the steady wind blows from either pole, according to the side of the equator, the atmosphere will be both dry and cool. An increase of warmth and atmospheric moisture, are indications of the approach of a Progressive Revolving Wind.

"*Sailing from Bermuda to New York.*—The first half of a revolving gale is a fair wind from Bermuda to New York, because in it the wind blows from the *east*; but the last half is a fair wind from New York to Bermuda. During the Winter season, most of the gales which pass along the coast of North America are Revolving Gales. Vessels from Bermuda bound to New York, should put to sea when the *north-west* wind which is the conclusion of a passing gale is becoming moderate, and the barometer is rising to its usual level. The probability is, more particularly in the winter season, that, after a short calm, the next succeeding wind will be *easterly*, the first part of a fresh Revolving Wind coming up from the South West quarter.

"A ship at Bermuda bound to New York or the Chesapeake, might sail whilst the wind is still *west*, and blowing hard, provided the barometer indicate, that this West wind is owing to a Revolving Gale which will veer to the *northward*. But as the usual track which gales follow in this hemisphere is Northerly or North-easterly, such a ship should be steered to the Southward. As the wind at *west* veers towards *north-west* and *north*, the vessel would

come up, and at last make a course to the westward, ready to take advantage of the *east* wind, at the setting in of the next Revolving Gale.

" *Sailing from New York to Bermuda.*—A vessel at New York and bound to Bermuda, at the time when a Revolving Wind is passing along the North American coast, should not wait in port for the westerly wind, but sail as soon as the first portion of the Gale has passed by, and the N.E. wind is veering towards *north*; provided it should not blow too hard. For the *north* wind will veer to the *westward*, and become every hour fairer for the voyage to Bermuda.

" *Sailing between Halifax and Bermuda.*—A great number of gales pass along the coast of North America, following nearly similar tracks, and in the winter season make the voyage between Bermuda and Halifax very boisterous. These gales by revolving as extended whirlwinds, give a *northerly* wind along the shore of the American Continent, and a *southerly* wind on the Whirlwind's opposite side far out in the Atlantic. In sailing from Halifax to Bermuda, it is desirable for this reason to keep to the westward, as affording a better chance of having a wind blowing at *north*, instead of one at *south*; as well as because the current of the Gulf Stream sets vessels to the eastward.

" *From Barbadoes to Bermuda.*—When vessels coming from Barbadoes or its neighbouring West India Islands, sail to Bermuda on a direct course, they sometimes fall to the eastward of it, and find it very difficult to make Bermuda when westerly winds prevail. They should therefore take advantage of the trade wind, to make the 68° or 70° of West Longitude, before they leave the 25° of latitude.

" *Sailing from England to Bermuda.*—On a ship leaving England for Bermuda, instead of steering a direct course for the destined port, or following the usual practice of seeking for the trade winds, it may be found a better course, on the setting in of an *easterly* wind to steer west, and if the wind should veer by the *south* towards the *west*, to continue on the Port tack, until by changing, the ship could lie its course. If the wind should continue to veer to *north* and as it sometimes does even to the *eastward of north*, a ship upon the starboard tack, might be allowed to come up with her head to the westward of her direct course. On both tacks she would have sailed on *curved lines*, the object of which would be, to carry her to the westward against the prevailing wind and currents. There is reason for believing that many of the Revolving winds of the Winter season originate within the tropics: and that ships seeking for the steady trade winds, even further south than the tropic at that period of the year, will frequently be disappointed. How near to the Equator the revolving winds originate, in the winter season, is an important point not yet sufficiently observed. The quickest voyage from England to Bermuda therefore, may perhaps be made, by sailing on a course composed of many curved lines, which cannot be previously laid down, but which must

be determined by the Winds met with on the voyage. This principle of taking advantage of the changes of Revolving Winds, by sailing on curved lines, is applicable to high latitudes in both hemispheres, when ships are sailing westerly."

W. R.

Government House, Bermuda,
21st March 1846.

126. While correcting this, I read the account of the *Great Western* Steamer committing the old blunder of *steaming into* a hurricane (Cyclone) in the Atlantic Ocean, in which she was nearly lost. She had it beginning at S.W. and veering gradually to N.N.E. Her drift in distance steamed, in the interval of 36 hours, is not given, but it is clear that she was on the South side of a hurricane (Cyclone) travelling about from West to East, taking her to have steamed and drifted about 100 miles to the N.W.

In the same hurricane (Cyclone) a Royal Mail Steamer from the West Indies to Bermuda having met the hurricane (Cyclone) on her track, slacked her speed to allow the centre to pass her, and made a fair wind of its southern quadrants to her port.

127. A vessel from Europe, bound, say to New York, meets with a strong S.S. Easterly gale and falling barometer, about the meridian of Bermuda. Here the seaman will observe, by the tracks and his Storm Card, that he is on the *Eastern side* of the storm (Cyclone) which is travelling *towards* him on an E.N.E. or North Easterly course, and that if he stands on he will inevitably meet it. To run off to the N.W. till he has bronght the wind to, at least, E.N.E. or N.E. and his barometer is rising, would be the means of getting out of the way of the centre; but it is very uncertain what are the sizes of the hurricanes (Cyclones) hereabouts, and the distance he might have to run; most seamen will probably therefore prefer heaving to and allowing the centre to pass them, when the wind will become a fair one.*

* It has been noted before that these situations, when a ship is directly on the average track of the storm (Cyclone) are those of the greatest difficulty on two accounts. It is difficult to say beforehand, unless great attention has been paid to the run and veering of the wind, on *which* side of the track the vessel is; and the rate of travelling is here a serious question on which

128. **Coasts and Seas of Europe.** If I venture to give any examples for these parts, it is rather with the hope of exciting the attention of seamen to the subject, than as founded upon any positive knowledge which we as yet have. It is *probable*, as before-stated, (p. 27) that the great Atlantic storms (Cyclones) sometimes reach the coasts of Spain and Portugal, and that their Northern verges extend to the coast of Ireland.

We have also examples, tolerably well authenticated, of true circular storms (Cyclones) passing over Great Britain, and of small hurricane-like storms, both as to force and veering, prevailing between the Chops of the Channel and Madeira, but of the storms of the inland seas, such as the Mediterranean, Ægean, Baltic, &c. we have no defined accounts, though their suddenness and severity render it most desirable to learn if they be rotatory (Cyclones) or not. I shall thus merely adduce cases in which the seaman may use the Storm Card "to consider with," and then if his experience should justify it, guide himself by the help which they afford.

129. I suppose a vessel bound into the Channel in Lat. 47° North and Long. 20° West with a smart gale which has veered from East to E.N.E. and a sufficient fall of the barometer to induce the supposition that this may be a rotatory storm (Cyclone) travelling towards the Channel or Bay of Biscay.

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every thing depends, and it is difficult therefore to judge if by running off for a few hours we shall really be getting farther *out* of the way. In the instance given above, the centre bears about W.S.W. and the track may be due E.N.E. *or* N.E. If it be only E.N.E. there might be time to cross in front and round the Northern verge of the storm; but if it be travelling N.E. the wind and sea may become too heavy to allow of standing on, and the run made would then only have brought the vessel directly into the path of the focus: with the encumbrance of her sail, if she meets it unexpectedly. Nevertheless there may be many cases, such as urgent service, chasing, and the like, in which the sails, and even the chances of the masts going with them, are not worth considering, and it is therefore proper that the seaman should have all the resources and the risks before him, for it is not impossible that a case might occur in which he might by clever manœuvring inflict a share, at least, of the latter on an enemy. Every experienced officer can tell how often in coast cruising the chase escapes by her superior knowledge of the winds and currents.

The Storm Card will show forthwith that the centre bears S.S.E. of the ship, and though with the wind at E.N.E., if the ship can stand on the port tack, S.E. would offer most advantage, this may be leading her to keep company with the gale (Cyclone) and get worse weather; it may be therefore well to consider if standing 50 or 100 miles on the starboard tack, or due North, may not be the safer plan? and the barometer here will soon show if the distance from the centre has increased.

If heaving to be found necessary, from stress of weather, then the card will also show that being on the port side of the track of the storm (Cyclone), which may have come up from the Bermudas, and in all probability is travelling to the E.N.E. or N.E. the port tack is the one to heave to upon, and that the wind will draw aft and not forward. It will also, by moving it along an average track, warn against the error of running again into the storm (Cyclone) when it has passed by; which may be avoided by keeping a little to the Southward, and if possible on the South-western quadrant of the storm (Cyclone), where the wind is from N.W. to West. An outward-bound vessel, from Europe to America, would of course manage quite differently, her business being to profit all she can by being on the favourable side of the tempest (Cyclone), and to avoid (especially if it be a slow-moving one) running into the heart of it, where the violence of the wind, though fair, must expose her to broaching to if she approaches it too closely.

130. If we place a Storm Card between the Coast of Ireland and Cape Finisterre, we shall understand as before said (p.28), how a revolving storm (Cyclone) of 600 or 800 miles in diameter may fill up the whole Bay of Biscay and the entrance of the Channel, and while it is a Westerly storm on the coasts of Spain, be a Southerly one for those of France, and South-Easterly and Easterly for the Channel and coast of Ireland. A ship from Cape Clear bound to Gibraltar might, in some cases, profit by making a somewhat curved track, so as to pass *behind* the centre, and have full room to take advantage of the North Westerly and Westerly gales where the diameter of the storm (Cyclone) was not excessive.

131. In the narrow seas of Europe we have usually too little sea-room to do much in the way of profiting by circular storms (Cyclones) if they occur; but the time to heave to, the tack to heave to upon, and often the direction in which to steer, so that, all things permitting, their excessive violence may be best avoided, are matters of great importance to the seaman; for they may at least be to him the difference of arriving at his port with a damaged cargo and a strained leaky ship, or safe and sound when others have been torn to pieces. Thus in a N.W. storm in the Gulf of Lyons, if we call it a circular one (Cyclone) we see that we are on its S.W. quadrant, and that to stand a little to the South would probably carry us from the more violent parts.

Again in the sudden and violent storms of the Black Sea, a ship having left the Channel of Constantinople and being bound to Odessa, might if meeting with a violent storm (Cyclone) *travelling to the Westward,* advantageously steer, at first, to the Eastward and then haul up gradually to the North, so as to carry a fair wind up to her port, while if she stood at first to the Northward she might get damaged by the strength of the storm, and driven considerably to the Westward. If bound however to Trebizond and the storm was travelling *to the Eastward,* she might also carry a fair wind the whole way by running with the Southern border of it. We do not know that the storms of the Black Sea are revolving ones (Cyclone) nor what are their tracks, but no intelligent seaman can look at a few old logs* of such storms, with the assistance of the Horn Card, without detecting by the veering of the wind and his track, if they were so, and how they travelled.

132. **Southern Indian Ocean.**—Off the Cape of Good Hope, ships bound to India and Australia are often detained for some days, and even for above a week, by strong North-Easterly, Easterly, and South-Easterly gales, in which little or no progress can be made, and they are for the most part lying to. Now these, very probably, are the Southern quadrants of great circular storms (Cyclones) which are passing to the Eastward, North of the vessel, and she may in

* Unfortunately none are obtainable in India, where I am writing.

all likelihood, by standing a degree or two to the South, get out of their influence into the regular Westerly gales prevailing there.

133. For as there is no sort of doubt that the West India hurricanes (Cyclones) of say 200 or 300 miles in diameter at most, expand in their progress along the coasts of North America and become great whirlwind storms (Cyclones) of even 1000 miles or more in diameter as they travel across the Atlantic in high latitudes, we may easily conceive the same thing to take place in both hemispheres, giving rise to Easterly or Westerly gales, according as the ship is on the North or South side of the circle.

Now let us consider the case of a heavy Westerly gale for a ship in Lat. 38° South, and between the Cape and St. Paul's and Amsterdam.

If we suppose a polygon of 32 sides for the 32 points of the compass, and each side of 96 miles, this will be about equal to a circle or circular storm (Cyclone) of a little more than 1000 miles in diameter.

If our storm (Cyclone) is travelling at the rate of 15 miles an hour from West to East, and our ship is on the Northern verge of it, we will take it that she is scudding at the rate of 11 knots due East with a heavy Westerly gale, as it is called.

But as the storm is moving at the rate of four miles an hour faster than the ship, its centre will in the 24 hours have made 96 miles more Easting than the ship, and this in our supposed polygon of winds, and we suppose no incurving, will have left the ship at the point where the wind is W.b.S., and we may suppose also less strong, for the centre of the storm (Cyclone) is more distant than it was from her, so that for the next 24 hours she may scud not more than 10 knots, and thus for this day the storm (Cyclone) will gain 120 miles upon her, and thus she will gradually fall out of the storm circle. If the ship's or storm's (Cyclone's) track be different, and approach to or diverge from each other, the results will of course vary.

As just noted, the heavy Easterly gales also at times experienced in these latitudes, and which so much detain outward-bound ships, are probably often referable to the same cause, namely, the ship, being overtaken by the Southern half of a great whirlwind storm (Cyclone), travelling to the Eastward, which may therefore begin

East, and end at S.E.; but if travelling slowly (or if, as seems sometimes to occur, followed by another of the same kind), it may take several days to pass over the ship, as its chord from the N.E. to the S.E. point would be about 680 miles, which even at 16 miles an hour (leaving out all account of the ship's drift) would require nearly two days.

If this view is a correct one, the remedy is to stand to the Southward, to get out of the storm circle into the usual stream of the Westerly gales; and with a homeward-bound ship meeting a Westerly gale, which she had good reason to suppose part of a rotatory one, to stand to the Northward. Every seaman will see at once how this applies in the Northern hemisphere, as, for example, in the circular storm gales (Cyclones) of the Atlantic, and in other parts of the world; and by placing his Storm Card on the chart, he will often find that he may save himself some days of "thrashing and beating," and his owner some wear and tear, by going a little round about: verifying perhaps the homely old proverb,

> "What can't be done by pushing and striving,
> May often be done by a little contriving."

134. Ships lying at the Bell Buoy at the Mauritius (Port Louis), and having every indication of an approaching hurricane (Cyclone) must consider, if it is one, like our tracks *u* and *c* Chart No. II., passing directly over the Island, or to the Northward or Southward of it. If passing directly over it, the wind, as will be seen by the Storm Card, will remain steady at S.E. till it shifts to the N.W. probably after a calm interval. If passing to the North Westward of the Island, the winds will veer to the S.E., East, and N.E., and if passing to the Southward and South Eastward of the Island, the winds from South will veer to the S.W., West, and N.W., so as to make the Island a dangerous lee shore in a few hours if a good offing be not run for. It is in this knowledge of what the winds *will be* (certainly) in a few hours that the seaman's safety, or his avoidance of serious damage often lies, and it is to the absence of it that mischief is in innumerable cases to be traced.

Mr. Thom, p. 229, quotes the case of a ship which "in the hurricane of 1840 slipped with the gale at S.E. hove to, and drifted

from the island, but the next day was carried back by the N.W. wind, and thrown on the reefs at the entrance of Grand River, at the place she had left."*

135. Suppose yourself in 10° South and 84° East Long. with a strong gale at W.S.W. and falling barometer; place your Southern Storm Card as before, and you will see (as you are now in the Southern hemisphere) that the Westerly winds place you on the *Northern* side of the hurricane (Cyclone) and that a W.S.W. wind makes the centre bear about S.S.E. from you.

Now if you are bound to the Northward you may profit by this, for all research as yet shows that the storm tracks are to the W.S. Westward hereabouts,† and thus the storm (Cyclone) is leaving you, while you are leaving it.

If bound to the Southward or South-Westward, however, (as to Europe, Australia, or the Mauritius) the case is exactly reversed, and you might, as you perceive, with a very little "carrying on to it" plunge headlong into a hurricane (Cyclone) of unknown fury. Your safe and proper plan is, if so bound, to steer off before the wind, or even N.E. till you raise your barometer a little. The wind you will find draw to West (the centre now bears South of you) and gradually to the Northward of West, when you haul up a point in an hour or more, *as your barometer* and the wind advise you, till hauling South

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* Mr **Thom** quotes also the case of the *Stag*, but, by an oversight, condemns her for running off from the Bell Buoy to the W.S.W. He forgot that, in a heavy gale the sailor often cannot choose, but must *venture* only to run with the wind two, or at most three points on the quarter; and then with extreme care for fear of broaching to, which the smartest vessels with the best helmsmen will at times do in spite of every care. Every sailor knows that in a fleet, for instance, all scudding with the same gale, while some ships will steer with one spare hand at the helm to help if wanted, others of the same size, merchantmen or men of-war, require three or four men at the helm and an officer to watch them; and withal will sometimes tear the wheel from their hands, and perhaps seriously hurt them if the relieving tackles are not carefully attended to.

† In one instance traced by me, (Memoir XI, Journal Asiatic Society Vol.) for a short time, and very slowly to the N.W., but standing North or N.N.E. would still carry a ship rapidly out of the vortex, in such a case as her barometer would quickly show. See Track VIII. Chart II.

and S.W. you have *sailed round* the storm, and have now literally—for it is almost an Americanism—"got to the other side of it", where it is a fair wind for you.

136. This simple manœuvre of sailing round a storm is especially useful here; for though of course a vessel may heave to and allow the storm (Cyclone) to leave her, yet the usual tracks are so exactly along or rather *across* the homeward bound routes, that after losing from six to twenty-four hours in heaving to, a ship would in most instances find, when she bore up, that in a few hours she was again coming down upon the body of the hurricane (Cyclone), and have again to heave to; so that in the end she would lose far more time than by sailing round it as I propose. I am not *supposing* this, but writing from facts. The ship *Orient*, Captain **Wales**, from Calcutta to the Mauritius hove to, to avoid running into a hurricane (Cyclone Track *i i* on the chart) and bore up to proceed, when she again in a few hours found she was getting into worse weather, and again hove to; repeating this bearing up and heaving to three times, an excellent instance of careful management.

The transport *Maria Somes*, with troops on board, committed the fatal error of running headlong into another hurricane close to the *Orient's* track, was dismasted and nearly foundering, *and suffocated fourteen persons for want of air during the tempest!* having all her hatches closed.

137. Suppose yourself bound to India or the Straits of Sunda, say in 20° S. and 75° East, and that the trade from fine clear weather and a high barometer becomes stormy, the barometer falls and the wind is at East or E.b.S.* This you will instantly see, by the Storm Card, is in all probability a hurricane (Cyclone) crossing ahead of you, and by heaving to for a few hours it will pass you, travelling to the W.S.W. just as a water spout might do. You will then probably have the wind from the N.E. and North, as your Storm Card will show you, and by standing to the Eastward your barometer will rise, and you will quickly find the Trade again.

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* And especially in these cases with a heavy cross sea from the *North* East or more Northerly.

138. The most recent instance in this latitude of this kind of careful management which has occurred, I give a little in detail, as being highly instructive. It is that of the ship *Earl of Hardwicke*, Captain **Weller**, from England bound to Calcutta, who was good enough to place his well-kept log and a private note book both at my disposal.

The *Hardwicke* was on the 26th December in 28° 42′ South, Long. 80° 46′ East, with her Barometer at 29.95, and with light, and latterly strong, breezes S.E. and North. Up to this time squally, thick, heavy, wild-looking weather, upper clouds coming from N.W., the next stratum N.E. and the lower scud, with the wind, fast from S.E. At midnight from 10 knots ran into a dead calm. Breeze was renewed again, and next day she was in 26° 14′ South, 81° 5′ East, with Barometer at 30.00, and confused sea, heaviest from S.W. wind East to E.S.E. and a strong Trade throughout. On the 28th in 22° 37′ South, 81° 00′ East, and Barometer 29.95; and on the 29th in Lat. 19° South, Long. 81° 00′ East, Barometer 29.71. strong Trade still, but squally and a confused sea, and barometer falling, made preparations for bad weather: upper clouds from N.E.

On the 30th in 17° 0′ South, 81° 41′ East, Barometer 29.75. To 8 A. M. running 6 and 8 knots to the Northward, but appearances threatening,* hove to, dense lurid atmosphere, very peculiar appearance at sunset the last two evenings. P. M. continued dark appearance to the North Westward, ran twice to the North and found the wind increasing, and drawing to the Eastward with thick weather, but always fine when going South; kept her South till it should clear off a little; a thick lurid appearance over the heavens, the sun only showing as through a dense veil with heavy leaden-looking clouds to the North and N.W.

Captain **Weller's** private note is: At 4 A.M. barometer not falling any more, made more sail to the Northward, weather became more squally with thick weather and heavy rain. At 8 A. M. a heavy squall from the N.E., shortened sail to close-reefed main top-sail, light Easterly air with a heavy arch to the Northward

* These cloud notes are of high interest, perhaps as we shall subsequently see, of higher interest than we suppose.

which kept nearly in the same position till noon, ship drawing to the Southward 3 knots. At 1 P. M. made sail again to the North and East. As we advanced, the weather became thick and squally until 4, when in a smart squall with thick rainy weather, not able to see fifty yards from the ship, wore to the South and shortened sail to close-reefed fore and main top-sails, the weather clearing a little, but an immense mass of heavy leaden-looking clouds, and over the whole of the heavens a very murky threatening appearance; sun at setting gave the whole a red lurid appearance, and every thing on board had a red tint. At 8 P. M. a fresh gale S.E. Although the sun and moon were visible during the day, yet they were only seen as through a thick veil. 30th December; Noon Lat. 16° 26′ South, Long. 81° 35′ East, Barometer 29.80. After midnight the stars began to shew, and the thick lurid haze went off, and blue sky was visible at daylight, but still a heavy leaden appearance to the Northward with a heavy confused swell, heaviest from the East.

In this capital instance of good management, there can be no doubt, that Captain **Weller** with the sacrifice of a few hours run, avoided running into a hurricane (Cyclone) on the South Eastern border of which he was, and of which he saw the body, in the bank and arch of clouds to the North and N.W. of him; as distinctly as one might see the smoke of a fleet of enemy's steamers, and stand back not to run in amongst them. The red lurid tint of the atmosphere is a peculiar characteristic of the approaching hurricane (Cyclone) in the Southern hemisphere, as we shall subsequently see.

139. If however in this position you are bound to the Mauritius or the Cape, you will see that you may nearly profit by it, steering only so far to the South as not to let it gradually approach you, and thus become too violent to run in with safety. For this your barometer and keeping the wind to the Northward of East will be sure guides. If the wind is to the *Southward* of East, you are *before* (to the West of) the meridian of the hurricane (Cyclone), and should haul more to the Southward out of its way.

140. But if in the Latitude and Longitude just stated, 20° South and 75° East, I have the wind South?

You are then right *before* the path of the tempest (Cyclone), and taking into consideration also the state and qualities of your

ship, as well as the distance of the centre as you estimate it from the barometer, you must manage to get out of the way of the terrific centre at all events.

The best plan is to steer off N.W. or N.N.W.* till the wind is at least S.S.W. and the barometer has decidedly risen, when you may haul North and either heave to or run on, as you are bound. Note here that, as will be subsequently shown when we come to speak of the barometer, that your barometer will be proportionably higher *before* the storm than when on either side or behind it. And also that as the hurricanes (Cyclones) here are from 200 to 400 miles in breadth, you must run at least one-third of that distance to be well out of harm's way.

The foregoing examples will also apply to the hurricanes (Cyclones) of the Straits of Madagascar and those between Cape St. Mary and the Natal Coast, which are all in the Southern hemisphere, and have all their tracks, *so far as we yet know*†, to the W.S.W. or Southward of West.

But about the Latitudes of Bourbon and Mauritius, there seems no doubt that the tracks of the storms *recurve* to the South, (see chart and at p. 33, what is said there of the *Serpent's* hurricane (Cyclone); and hereabouts the seaman must warily apply all his skill and attention to ascertain the track before he heaves to, and to be assured that if he has allowed the storm to pass him, he does not run into it again by crossing near the apex of the curve.

141. **The Arabian Sea.** We are here again in the Northern hemisphere, and must recollect that all the changes are different from those we have considered in the foregoing paragraphs. In the section on the Tracks of Storms I have adverted fully (p. 37) to the little that is known of the tracks of the storms (Cyclones) in this sea, and the possibility of their curving to the Northward towards

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* I give these apparently loose limits, because while a Man-of-War or fine-built Merchantman, well steered, might run for a long time N.W. with a gale at South, others could not venture to do so without great risk of broaching to.

† And this caution especially applies to those to the Southward, where it is quite possible, there may be a second recurving track, analogous to that off the Mauritius mentioned in the next paragraph.

the coasts of Persia and Arabia, which should be borne in mind; as also that at a few degrees from the Malabar coast, the hurricanes (Cyclones) appear at times to be sudden and violent, though of small extent.

Taking a storm (Cyclone) to begin at N.W. with a ship bound to Bombay, in Lat. 13° North, Long. 67° East, it will be clear that she should not stand on upon her North Easterly course, but run off E.S.E., hauling up East and gradually N.E. as the wind hauls to the S.W. which it will do, and this *may* be the best plan even for a vessel bound to Aden or the Persian Gulf instead of lying to. At all events she should not heave to with the wind at N.W., for should the course of the tempest (Cyclone) be very Westerly and its diameter small, the centre would pass very close to her. To run off to the S.E. or SW. if the season admits, so as to raise her barometer will be more prudent, and she may regain her former position by running partially round the storm (Cyclone) and taking advantage of the South Easterly breezes by which these storms (Cyclone) are usually followed.

142. **In the Bay of Bengal.** Supposing our ship in Lat. 14° North and Long. 89° East, or not far from the middle of the Bay of Bengal, with a strong squally gale at E.N.E., a falling barometer, and other indications of bad weather. We take the Northern card, and placing it so that the ship's place may fall, say on the outer circle just between "wind N.E." and "wind East," we have it of course at the place of the wind, E.N.E., and we see immediately that the centre of the storm bears S.S.E. from us.

Next, we know that the storms of the Bay of Bengal come generally from about the E.S.E., and travel to the W.N.W., so that we may say with tolerable confidence, "This is a storm coming up from the Andamans and travelling towards Coringa," and if bound down the Bay or to the Straits of Malacca, we may add, "and if I run on now, I shall run into the heart of it, for I shall in a few hours cross its track, before, upon, or close behind its centre, according to its rate of travelling." As no careful seaman would of course run his ship headlong into a waterspout, neither would he now hesitate, I suppose, to heave to for a few hours, when he will find that the wind has drawn gradually to East, and then to the

Southward of East *when his barometer will begin to rise*, and he may safely stand on. It is probable that in doing so he will cross a spot where the hurricane (Cyclone) has left its traces in a heavy confused sea. He will see also by moving his Storm Card to the W.N.W. *how* it is, that (allowing always for his drift or run,) the wind will in a rotatory storm change *as I have here described it:* and indeed what I have related above is, with some little difference of position, the case of a troop ship, the *Nusserath Shaw*, in April 1840, as shewn in my Third Memoir in the Journal of the Asiatic Society, Vol. IX, but with this difference, that her Captain, unfortunately, being in all probability desirous of profiting by the "fine fair wind," ran down 100 miles towards the track of the hurricane, which travelled up about 180 miles in the same time; and as the ship crossed it close to the centre she was dismasted, narrowly escaped foundering, and was obliged to put back at a ruinous expense to repair the damages! Several other vessels suffered from the same error, and two at least, the brigs *Freak* and *Vectis*, had to put back to Calcutta for repairs, after being near foundering.

143. Let us suppose now, with the card in the same place, that our ship is in the same Longitude as before, 89°, but in Latitude 11° or 11° 30′ North, with the same signs of bad weather, falling barometer, &c. and the wind at W.N.W. Placing the card as before *with the wind's place upon the ship's place*, we see that now, if bound South or to the Straits of Malacca, we may safely and surely profit by the fair gale; for the farther we get to the South or S.E., the more distant we are from the dangerous centre. On the contrary, if bound to the Northward, we should be standing on into danger, if we ventured, especially with a falling barometer to "carry on," since we should then clearly be nearing the centre, which now bears N.N.E. from us.

144. Assuming a ship bound to Calcutta in the month of October, in Lat. 18° N. Long. 88°, with a strong gale at N.b.E., and a falling barometer. The Storm Card will shew that this is probably a storm (Cyclone) coming up from the E.S.E. or S.E., and to lie to would be to lie in the track as if waiting for it, and that in a position in which if disabled there is a dangerous lee shore. A short run to the S.W. will raise the barometer sufficiently to assure the seaman that he is out of the way of the violent parts of it, when as the wind holds to the N.W., West, and S.W., he can soon sweep round its Southern and

Eastern border, and regain his lost distance without straining a rope-yarn. It will no doubt be some time before this plan, which will probably be called, "turning tail to one's port for a gale of wind," will be adopted; and many will prefer taking their chance, subjecting their ship to the wear and tear of three years in twenty-four hours, (to say nothing of loss and risks for which underwriters pay) and those who do so will of course not think it worth while to consider of the right tack to heave to upon; but this will be done once only. Those who have passed through a "real" hurricane (Cyclone) in the Bay of Bengal or West Indies, or a "genuine" tyfoon in the China Seas, will not mind sacrificing a little time to getting out of their way; and still less when they consider that, as before said, all that is gained in the run into, is lost in the drift *out of*, the fatal circle!

145. Supposing the ship in the same position but the wind from the S.W. or S.E.? This may safely be profited by, for we have as yet no example here of a hurricane (Cyclone) moving to the Eastward of the meridian, and the barometer and Storm Card will fully advise if it should be one of those (apparently rare ones) which move up on a N.N.W. course toward the Sand-Heads, so as to prevent the seaman from crossing into it.

About Ceylon and the Southern parts of the Bay, the same rules hold good, as also for the gales (Cyclones) which occur in Madras roads, Coringa, and other anchorages on the coast. To the management in these cases I shall advert in the Section upon that advisable in Roadsteads and Harbours.

146. **In the China Sea.** Suppose yourself in about Lat. 20° North, Long. 115° East, with the wind varying between West and N.W., a falling barometer and other signs of bad weather, being in the tyfoon months withal, and bound to Canton.

Place the Storm Card on the chart, and it will shew you, that in all human probability, this is a tyfoon (Cyclone) coming up from E.S. Eastward or down from the North Eastward, and that if you stand on upon your direct course, though you may indeed make 50 or 60 miles of latitude, you will be in the very track and heart of it; but that by steering away to the South Eastward, and hauling up gradu-

ally as the wind and your barometer guide, you will have allowed the storm to pass you, and have only made a little curve, as in the case of a head-wind. The case which I have supposed here, *really happened* between the 27th and 28th September 1809, when a fleet of four of the East India Company's China ships, by standing on 64 miles to the Northward, ran headlong into a tremendous tyfoon, in which the *True Briton*, a new ship, foundered, and the other three were not far from it! See Sixth Memoir, "Storms of the China Seas," Jour. As. Soc. Vol. XI.

147. Again, in the same Lat. and Long., with a strong Easterly gale, falling barometer, and all other indications of a tyfoon, and in the month of July, and your ship bound *down* the China sea or to Manila. The probabilities (or we may say at once certainties?) here are as before, and you may commit the same error by standing on; the centre of the storm (Cyclone) being South of you; but it is travelling more or less to the Westward or North Westward. If wind and sea yet allow, you may stand off to the N.N.E. when as your barometer rises you will be able to lay more Easterly, as the wind will haul to the S.E. and South, and with a very little sacrifice of distance you will allow it to pass you with but little more than the violence of a common gale for a few hours. If you stand on, the chances of your meeting the centre, and even of being involved in it *when disabled* are most imminent; and this last is perhaps the *most* dangerous situation in which a ship with sea-room can be placed.*

In 16° North, 113½° East, with the wind at W.b.N. and all the usual indications of a tyfoon (Cyclone) and bound to China.

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* The centre of a hurricane or tyfoon (for the tyfoon is yet more furious than the hurricane, using the words now to designate force only), is always an awful situation for the best found, manned, and perfectly prepared ship, even were she the smartest and stoutest frigate in the navy. Now if we suppose a disabled, and consequently unmanageable ship in this position, with a mast or two hanging by the lee chainplates, and thumping at her bottom or rudder, and this in the midst of "the pyramidal sea" which can only be likened to a boiling cauldron, flying mountains high in all directions, the most reckless sailors, or landsmen, may suppose it worth while to avoid the chances of such a purgatory.

If you stand on you get into the heart of the mischief, but by running away to the E.N.E. and gradually North, which is about your course, you will avoid it, and perhaps really lose no time at all in the end.

148. One case, which affords three lessons at once, has occurred in this sea, and should not be omitted. It was the subject of a special Memoir* by me, in consequence of a reference from the Marine authorities at Calcutta, of which the object was to ascertain as nearly as possible on what day the transport ship *Golconda* was lost. The results of the enquiry showed that of three ships which must have been close together in a double tyfoon in September 1839, Tracks XV. and XVI. on our chart—one, the *Thetis* of London, perfectly aware of her position, and her Captain well acquainted with the Law of Storms, hove to at the right time and place, and sustained no damage. The second, the *Thetis* of Calcutta, ran on, evidently in ignorance, till she could run no longer, lost her mainmast which crushed her pumps in its fall,† had three feet water in her hold, and narrowly escaped foundering; and the third, the *Golconda*, which with 300 Madras troops, their officers, followers, and her crew had nearly 400 souls on board, ran up and was no doubt caught at the meeting of the two tyfoons (Cyclones) and foundered!

149. The most recent instance of serious mischief, detriment to the public service, and useless risk of valuable lives and property by disregard of the rules of our science, occurred in this sea in June (28th and 29th) 1846; in which month the Honorable Company's War Steamer *Pluto*, bound from Hong Kong to join the force off Borneo, having the wind from the Eastward in the S.W. monsoon and in the tyfoon months, with a falling barometer and every other indication of a tyfoon, (Cyclone) steamed directly on her course, making one of South 32° West, while the tyfoon was travelling up to the North 30° West. She of course met the calm centre and shift, with the pyramidal sea, and indescribable fury of the winds found there. She

* IVth. Memoir, Jour. Asiatic Society, Vol. IX.

† Builders, ship-owners, and underwriters should note this accident, and place the pumps so as not to subject them to this serious risk, for it must have occurred before, and doubtless have occasioned the foundering of ships?

lost her funnel, rudder, &c. &c. and was almost foundering when the storm (Cyclone) left her. She then put back, and being of course nearly unmanageable drifted on the rocks at Hong Kong, but was saved by the boats of the *Vestal* frigate fortunately lying there.*

150. **In the Northern and Southern Pacific Ocean.** We have usually here abundant sea-room, but our difficulty will lie, till more knowledge is collected, in judging of the tracks of the storms (Cyclones.) The careful seaman will not fail to apply here with due care the method I have given (at p. 79), for finding what the approximate track is, and guided by that, and by analogies drawn from what is known of other parts of the world, will rarely I should suppose, be unable to avoid the worst parts of the hurricanes (Cyclones) he may meet with. He can confer no greater obligation on nautical science than by carefully registering his own and collecting the experience of others, to enable us to lay down rules for him here with as much certainty as in other parts. He will find in chart IV. a few tracks in the Northern Pacific; and at p. 84, a striking instance is given of doing exactly what should *not* be done, and the mischief arising out of the error. For the Pacific, and for the present, I can only then recommend to him the careful study of what is said of the Southern Indian Ocean, both as to tracks and stationary storms, and of the little information collected, p. 44 to 53. It is *probable* that the tracks may approach to those of the Indian Ocean, but the groups of Islands, particularly when high, may occasion great variations.

151. I have not in these examples for practice, referred at all to the incurving of the winds, because it will perhaps rarely be required that the seaman should consider it, since when he gets to where it is of considerable amount he is in all probability too far involved in the storm (Cyclone) to make it a considération influencing his management; and if he has, either while lying to or scudding, the winds "alternating" as described at p. 74, he will take the mean

* See chart No. IV. Track *j*. I drew up a detailed investigation of this error, which the Government of India did me the honor to lithograph, with the chart accompanying it, for the instruction of its Steam service. See also Naut. Mag. for January 1847, p. 12, for a capital lesson in this sea.

as the average direction of his wind, as in fact he often does in fine weather, when the wind is a little variable. In his examination of old logs, however, and especially those of Fleets or of numbers of detached ships, he will find this element of much importance in settling correctly the place of the centre.

152. **Recapitulation of various cases of error and of good management.** I had at first intended, as will be perhaps noticed by those who saw the prospectus of this work, to make a separate section of examples of ships heaving to on wrong tacks, running into, profiting by, or avoiding storms; but I have thought it more useful, as I proceeded, to adduce a few striking examples of good or erroneous management, and consequent advantage, loss, or mischief in the preceding sections; so that the precept and the warning against neglecting its practice might go together, and be thus perhaps more forcibly impressed on the mind than if separated. I merely recapitulate here, then, what has been instanced as to these separate heads :—

page

Heaving to on the wrong tack. Admiral Graves' Fleet with the *Ville de Paris,* 88

Running into Storms. (Cyclones.) H. M. S. *Swift,* with Company's Fleet in the Northern Pacific, ... 84

The *Great Western Steamer,* Northern Atlantic, ... 100

Maria Somes in Southern Indian Ocean, ... 107

French Frigate *La Belle Poule* and Corvette *Le Berceau,* Southern Indian Ocean, ... 34

Nusserath Shaw, and other ships, Bay of Bengal, ... 112

Company's Fleet, China Sea, 1809, ... 114

Transport *Golconda,* China Sea, 1839, ... 115

H. C. Steamer *Pluto,* China Sea, 1846, ... 115

Profiting by a Storm. Royal Mail Steam Packet in the Northern Atlantic, ... 100

Ship *Lady Clifford,* Coromandel Coast, ... 123

153. **Ships prevented by their situation in the Storm Circle from running into the Centre.** I mean by this, ships the Commanders of which really would, if they could, have driven

their ships headlong into the midst of a furious hurricane (Cyclone), in which dismasting would have been perhaps the least they could have escaped with! They have not done, and do not do this *knowingly*, but hundreds, there is no doubt, are yet doing and will yet do it for some time. In fact in every case in which the Mariner meets with that quadrant of the storm (Cyclone) which gives him a foul wind, he is, I must say, sadly tempted to wish the wind was "but a few points the other way," yet these few points, obliging him to lie to, are in fact his safeguard from the mischief he would plunge into if he could: an example will make this clear.

On our chart No. III. will be seen, marked XII. the storm of the *Briton* and *Runnimede*, which was indubitably destruction to those two fine ships; and by placing the Storm Card over the track, it will at once be seen that a ship about the Island of Narcondam must have had the wind Easterly, and one a little to the East of it the wind well to the Southward of East and South Easterly. Now at the very time the *Runnimede* and *Briton* were driving helpless and dismasted round and round the centre and finally on shore, the ship *Prince Albert, bound to the Southward*, was lying to off Narcondam, with a gale at S.E. and was thus prevented from running farther down towards the vortex.

154. **Proofs of the accuracy of the Rules and deductions, after publication.** The seaman who has not studied our new science, will scarcely believe that by means of it, when clearly understood, nothing is more easy than to predict beforehand, or to declare after the event, what winds and weather ships under given circumstances have had or may expect; and yet not only may this be done almost with certainty for single ships and storms (Cyclones) in given positions, but, which is perhaps still less credible at first sight, we have found that long after the track of a hurricane (Cyclone) has been traced, and the chart lithographed and published, other ships' logs of the same storm have been obtained, and when their position has been carefully ascertained and laid down, it is found that they had the wind nearly or exactly as the Storm Chart shewed, and this even where the Storm Circle was laid down by the logs of two ships only, or even of one!

Now the strongest possible proof of the truth of any natural law is, that it shall shew, and predict as it were beforehand, what *has* happened, or *would* happen under certain circumstances; and in these cases the prediction is made, and even printed and published, that a whirlwind storm (Cyclone) of a certain size *must* have passed on a certain track, at a given rate on a given day and hour; and *therefore* as it did so, all ships in certain positions *must* have had winds of certain violence, and blowing from such and such points and no other; and so it proves to be. I quote one or two of these cases which have occurred, to shew how satisfactorily the seaman may rely upon the results obtained.

155. In my Third Memoir* I had lithographed my chart, and, principally from the log of a single vessel, the *Nusserath Shaw*, (which, however, had the centre passing close to her) placed the track of two days as there laid down. I then obtained the log of another ship, the *Marion*, which also lost her mizen-mast in the same hurricane (Cyclone) and in placing her on the Chart it was found, not only that the track of the hurricane had been correctly marked, but moreover that its rate of travelling, which had been assigned by two ships' logs to be on an average for the 24 hours 14¼ miles an hour, was for six or more hours, with the *Marion*, 16¼ miles per hour, so that its true rate was probably about 15¼.

Mr. **Thom** also, p. 342, refers to a case, that of the ship *Patriot*, in which, after his chart was constructed and engraved, for the Mauritius hurricane of 1840, the log was obtained and found exactly to coincide with what had been laid down.

156. Several other instances have occurred to myself and to Mr. **Redfield**, Col. **Reid**, and Mr. **Thom** in which we should have been able to say to the Captain of a ship relating his wind and weather at a given time—

Stop: Did you then run on, or heave to?

Oh! I carried on to it of course.

Very good: then you soon found the winds veering to——and had a larger share of the hurricane than you looked for?

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* Journal Asiatic Society, Vol. IX.

Yes, I lost my mizen-mast, top-masts, boats and sails, and had my decks swept, and four feet water in the hold, *but how the d——l did you know that?**

Many more cases may be cited in all these sections § 147 to 150, but for brevity's sake I have noted but a few.

157. **In Roadsteads, Harbours, Open Coasts, Anchorages, and Rivers.** Tremendous as the Hurricane and Tyfoon are at sea, the mariner is well aware that there is one situation in which they are invested with tenfold danger; and this is when riding in open anchorages, or where caught by them on lee shores. To get an offing is then his only chance; and yet how often do we hear of a dozen of ships putting to sea, of which three or four are never heard of, and three or four return dismasted, or otherwise so seriously damaged as to be condemned. No doubt this often arises from ships being ill prepared, too light, or badly manned; but there is no doubt also, as we shall soon see, that it often arises *from steering the wrong course!* The mariner looks only to gain an offing as fast as he can, and is not dreaming that on the course he runs, he is steering a direct course to meet the furious focus of the hurricane (Cyclone), and the shift of wind it brings with it; and this too perhaps in a light ship† and with top-gallant masts on end and top-hamper aloft, not having time to get them down, till it was no longer safe to send men aloft. Capt. **Langford** in the paper quoted (p. 1) speaks fully of this, and advises the practice of running to sea in the West India hurricanes; and seamen well know in how many parts

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* I have really had more than one such conversation, under circumstances which (and this created the astonishment) almost excluded the possibility of my knowing by any chance what had happened to the ship; as speaking of an old gale of 10 or 15 years' date, and the wonder was always that we could predict how the wind veered.

† It is not long ago since a very fine teak-built East Indiaman was utterly dismasted, nearly lost, and so strained that she sold for a fifth of her insured value, or thereabouts, in consequence of putting to sea from Madras Roads in an approaching hurricane (Cyclone) with top-gallant masts on end—and this with ample time and warning from the Fort to get them down! Had she known which way to steer, she might, even in this state, have got off with the loss of a top-mast or two!

of the world it is necessary to ride in certain months with the expectation of being obliged to slip and run to sea at very short notice. The question I now propose to examine is, what ought to be the course steered, *for the greatest distance from the land may not always be the best offing!*

158. Let us as an instance, suppose a ship lying at, or becalmed close in with, any part of the South Coast of Jamaica, between Portland Point and South Point Negril, with every indication of a hurricane, and the wind at N.E. blowing already strong. From the average of the tracks (p. 25) he will see that the hurricane is probably coming up from the E.b.S. or E.S.E., and his Storm Card (which I repeat is the hurricane *ready-made* for him to manœuvre with)* will show him that though his present situation may be now a tolerably safe anchorage, or that it is a good breeze for running to sea with, yet remaining is out of the question, for the hurricane will shift to the S.W. or dead on shore, and if he runs to sea with his North Easterly wind without due caution, he may find the hurricane (Cyclone) veer rapidly to the North and N.W., when if an accident should occur, (even should he avoid the centre) he may be in a disabled state with the cays of the Pedro Bank under his lee. By running out at first well to the Westward, and then to the Southward before he heaves to, he may cross in front of the storm without damage, if its rate and time allow him; or at all events, if the track of the storm (Cyclone) lies well to the West, and he can keep on the North or right hand side of it, obtain a clear offing West of Point Negril as the wind draws to the East, S.E., and South, where it will leave him.

159. Captain **Langford** in his paper (Phil. Trans. for Oct. 1698,) speaks of "the benefit and experience he has had in foretelling hurricanes" as follows:

"That whereas heretofore they were so dreaded that all ships were afraid to go to sea, and did rather choose to stay in the roads at anchor than to run the hazard of the merciless sea, though never ship escaped at anchor, but was cast a shore oftentimes twenty to thirty yards dry from the wash of the shore and the vessels set whole. ——"

* And he will find it as advantageous as the gambler does the looking-glass when he can see his adversary's cards in it at whist.

He then gives directions for preparing a ship for sea, and continues:—

"And they may, having their ships in readiness, stay in the road till the storm begins, which is always first at North, so to the N.W. till *he* comes round to the S.E. and then *his* fury is over. So with the North wind they may come away to the South to get themselves sea-room for drift, if the S.W. wind, where *he* blows very fiercely; by these means I have by God's blessing preserved myself in two hurricanes at sea, and in three on shore, and have had great advantages by it."

He gives instances of preserving his own ship from damage, and at Nevis, in 1667, of a fleet under Sir John Berry in the *Coronation*, putting to sea by his advice before a great hurricane, and coming back again safe in four or five days, "to the great admiration of the French, then our enemies." And he relates that a Capucin Friar in his sermon to the French, said,

"You may now see your wickedness in praying for a hurricane to destroy "the *English* fleet, when you see they are all come back safe, and we have "not a house left to serve God in, nor for our own convenience, nor forts, "nor ammunition left to defend ourselves against these preserved enemies."

It is curious to find 150 years ago, so striking an illustration of the advantage of our science on so considerable a scale; and I trust we shall again find, if the misfortune of war is forced upon us, that now, as then, the science and skill will be on the British side. Let every Seaman then who can contribute a line to it remember, that his notice *may* be important enough to influence the fate of a ship or a fleet!

160. Let us take the case of Madras roads, a Coast which lies North and South. Here the hurricanes (Cyclones), which are at times of such fury, that no vessel can lie with the remotest hope of riding them out, and the surf breaks in nine fathoms water!* which is in from four or four and half miles from the shore, come in from East to S.E.; that is, their track is *from* that quarter, or perhaps

* In the hurricane of 1809, when the *Dover* frigate was lost, it did this; and, the wreck of a vessel which had been blown up in 8 fathoms water, twenty years before, was hove on shore! The expedition to Java, of probably 70 or 80 Transports and Men-of-War, had sailed but a few days before, but steering to the Southward fortunately escaped.

from E.S.E. on an average; see Chart III. The storms (Cyclones) usually begin from N.E. or N.N.E. but at times from North.

The Storm Chart will shew that without allowance for any "flattening in" as explained at p. 76, these winds indicate hurricanes (Cyclones) coming up from the S.E. to East. We take the average as before and say E.S.E., and we will also allow the storm (Cyclone) to have an average diameter of 200 miles; that is, that when we slip, its centre is 100 miles E.S.E. from the anchorage. We have the wind N.N.E.

Now to run out E.S.E. and as long as we can carry on, with the wind about abeam or a little abaft it, has been the usual rule, but the Storm Card will forthwith show that this is running out to meet the focus. If S.E. be adopted, it will be seen by a little calculation, that in about 16 or 18 miles, or in the first two hours run, the wind will have hauled to the N.b.E. or more Northerly, and that in an hour or two more it will be to the Westward of North, though probably the barometer may still fall, when the course can be made more Southerly to raise the barometer by increasing the distance from the centre; and then Easterly to "sail round the heel of the Storm" (Cyclone) so as almost to be in with the anchorage at the first fine weather. All this of course if the wind be not too violent, the sea too heavy, or the ship crank, or steering too wildly or dangerously. At all events if heaving to *must* be adopted (on the port tack of course as being well in the left hand side of the circle), every seaman can see that he has thus avoided two dangers, the being disabled by the fury and shifts of the centre, and the being drifted into the Northern or right hand semicircle, where the winds and currents of the storm are all more or less from the Eastward, and therefore *towards* the shore, while on the other half they are as much off it: so that even should a misfortune have befallen him he has a clear drift to sea while rigging his jury spars to get back again.

161. Captain **Miller**, of the ship *Lady Clifford*, has given us a capital instance of this management. In the Bay of Bengal storm (Cyclone) marked VIII. on our Chart, he was lying at Nagore, an open roadstead, and as the centre passed close to Pondicherry he had the winds Westerly. Being bound to Madras, and well acquainted

with the law of Storms, he weighed on the 24th October, with a gale at W.N.W. and stood out to the N.E., ran round the heel of the storm, and on the 26th anchored in Madras Roads, having carried the wind, veering in 16 hours from W.N.W. to S.E.

162. **In Rivers.** Ships in large rivers, may be able to derive much benefit from weather shores in storms, and it may often become with steamers, boats, and small craft, and at times with ships in the smaller rivers, of great importance to know that the shift or veerings of wind will take place in such or such a direction rather than in another; for by this knowledge they can often run at the commencement of a storm for an anchorage at which they can lie sheltered through the whole of it; or they can, if anchored on a weather shore, profit by the lull to get over to the other before the shift of wind comes on, which would convert their former shelter into a dangerous lee shore.

163. Let us as an example, take the Hooghly or Canton river, both much frequented and running about North and South towards their mouths, and suppose ourselves in them exposed to a hurricane (Cyclone) crossing them from East to West, in a launch with treasure on board, or in a steamer.

It is clear that for the first half of the tempest if the wind is to the Eastward of North, the centre will pass to the South of the boat, and as the wind will be N.E. and East, and South Easterly, the Eastern shore or any bank sheltering from these quarters is safe; but that if obliged to anchor to the South of a bank or island, when the centre is passing exactly over the boat's position, the latter part of the gale (Cyclone) may drive her on shore, or sink her at her anchors. The Card also shews how, if the wind is to the Westward of North it will veer to the West and S.W., and thus perhaps render an apparently safe berth really dangerous, if due precaution be not taken.

164. In a word, the Law of Storms will here as in so many other cases, *fore-warn* the mariner of what is to come; "and fore-warned is fore-armed." The tales which we have all read of the wind's "*unfortunately shifting to the opposite quarter*, when "the boat (or ship) was driven on shore and all hands perished,"

will be changed into, "During the lull, (or when the wind had veered to ——) the boat (or ship) in due anticipation of the latter part of the hurricane (Cyclone) changed her berth to the —— shore, where she safely rode out the remainder of it without damage." And let me add, that every officer and commander of whom this shall be said or written, will be held in that degree of professional esteem which is the rightful meed of such careful and scientific management of the lives and property entrusted to his charge, as contrasted with the fatalism, the fool-hardiness, or the helplessness of ignorance.

PART IV.

OTHER PHŒNOMENA CONNECTED WITH STORMS; STORM-WAVES AND STORM-CURRENTS. 2, INSTANCES OF THESE AND OF THEIR PROBABLE EFFECTS. 3, INUNDATIONS FROM THE STORM-WAVE. 4, PYRAMIDAL AND CROSS SEAS EXPERIENCED IN STORMS, AND SWELL FELT AT GREAT DISTANCES FROM THEM. 5, NOISE OF STORMS. 6, PASSAGE OF THE CENTRE OF STORMS. 7, SIZES OF THE CENTRAL SPACE OR LULL. 8, ELECTRICITY, MAGNETISM, ELECTRO-MAGNETISM, AND EARTHQUAKES. 9, ARCHED SQUALLS, TORNADOS, &c.

165. **Storm-wave and Storm-current.** These two phœnomena, of which the very names will be probably new to most of my readers, certainly exist, and often to an extent little dreamed of. They have also, I have no doubt, frequently occasioned losses which were quite unaccountable at the time, and thus, as being in effect a sort of *unknown, capricious, and sudden currents arising in the midst of tempests*, demand the most serious attention of the careful mariner: I begin with the Storm-wave.

If any of my readers have ever observed the passage of a whirlwind or water-spout across a river or lake, they may have noticed that it raises the water above the level as it travels along, and that light floating bodies, such as pieces of wood, or even sometimes the wrecks of boats upset in its passage, are often brought from the middle of the river or from the other bank to the shore where it lands. This is in miniature a Storm *Wave*.

166. Colonel **Reid**, (p. 523, 2nd edit.) says —

"If a revolving power, like a whirlwind, were the only one exerted, it might be expected that the level of the water would be diminished at the centre of the vortex, though heaped up towards the verge of the storm. But it may be possible that a wave of a round or oval form, moving onward like a tidal-wave, but at the rate of the storm's progress, may accompany the storm in its course, and that its height may depend on the degree of atmospheric pressure, modified by the revolving power of the wind. The impulse in the direction of the storm's course being given, and maintained for a few hundred miles, currents very similar to the ordinary currents of the tidal-wave might be created, so that if the effect produced by such a wave is added to the spring-tides, it might assist in causing those inundations in flat lands which often occur in violent storms. It will, therefore, be very desirable to note the height to which the tides rise on the leeward side of islands, particularly those lying at a distance from and influenced by continents."

167. Every seaman has also seen that under a water-spout the sea is boiling and foaming, and rising up, and travelling along with the spout, in a space of perhaps some hundred yards or more in diameter,* and he can suppose that, if a boat could live within it, it might be carried along as far as the water-spout travelled, which would then be also a miniature representation of what we suppose to take place in the case of the Storm-wave; which, *at present*, for we want information greatly on this as on so many other points; we suppose to be somewhat as follows:

As there is no doubt that the atmospheric pressure† when diminished in any one particular point of the globe occasions a temporary rise of the waters under this point, which is pressed up by all the rest, and that at the centre of hurricanes (Cyclones) a diminution of pressure which varies from an inch, to two and two and a half inches of mercury occurs, so there is no doubt that at this peculiar part of the centre the water is raised a little more than a foot for every inch of fall of the mercury, or about two feet in

* The black column of a small water-spout where narrowest, will often subtend a horizontal angle of a degree at least one would suppose? though I do not know that it has ever been measured. An angle of 1°, at a mile distance requires the object to be about 31 yards in diameter.

† Most seamen are acquainted with the meaning of this term; such as are not, will find it briefly explained in the following section, where the Barometer is treated of.

ordinary rotatory storms (Cyclones,) and proportionably over the whole area of them. The incurving of the wind, as already explained (p. 70) must also have a tendency to keep up and support a mass of water, at and towards this part, and we assume that this mass of water, or at all events a body floating upon it, is borne by the conjoined action of the wind *and* this wave, onwards in the direction of the path of the storm. This is what we denominate the **Storm-wave**, and what I have quoted and said is the **Theory** or theoretical description of it. We shall come forthwith to the proofs I have been able to collect of the fact of this phœnomenon so occurring, and with more of these we shall obtain in the end a **Law** for its action in all cases, and our estimates of its effect will be then more certain.

168. Sir **Henry De la Beche**, in his "Geological Report on Cornwall, Devon and West Somerset," p. 11, has the following remarks, which I will not attempt to abridge, confirming so exactly as they do what has been just said. I have however marked a few passages in italics.

"Mr. **Walker*** has observed, with respect to the influence of the pressure of the atmosphere upon the tidal waters on the shores of Cornwall and Devon, that a fall of one inch of the mercury in the barometer corresponds with a rise of sixteen inches in the level of the sea, more than would otherwise happen at the same time, under the other general conditions; a rise in the barometer of one inch marking a corresponding fall in the sea-level of sixteen inches. This he has found to be the usual rate of such alterations in level; but very sudden changes in the pressure of the atmosphere, are accompanied by elevations and depressions equal to twenty inches of sea-water for one inch of mercury in the barometer. Regarding the whole pressure of the atmosphere over the globe as a constant quantity, all local changes in its weight merely transfer a part of the whole pressure from one place to another; and hence he concludes that the subjacent water only flows into, or is displaced from, those areas where, for the time, the atmospheric pressure is either less or greater than its mean state, in accordance with the laws which would govern the condition of two fluids situated in the manner of the atmosphere and sea.† We might account for the difference observed by Mr. **Walker**, in the amount of depression or elevation of sea-level produced by sudden changes in atmospheric pressure, by considering that a sudden impulse given to the particles of water, either by suddenly increased or

* Assistant Master Attendant H. M. Dock Yard, Devonport.

† Walker, MSS.

diminished weight in the atmosphere would cause a perpendicular rise or fall *in the manner of a wave*, beyond the height or depth strictly due to the mere change of weight itself.*

"As regards the influence of the winds on the mean level upon the south coast of Cornwall and Devon, Mr. **Walker** observes that East and West winds scarcely affect it, but that Southerly winds raise the sea above it from one to ten inches, and off shore winds depress the water beneath it as much according to their force. On the morning of the 29th November 1836, when the velocity of the wind was estimated at about one hundred feet per second, the sea at Plymouth was raised three feet six and a half inches above the mean level, the greatest height above the equilibrium level he has seen. The hurricane began at S.W., and the barometer was very low; therefore this great increase in height is due both to the wind and diminished atmospheric pressure. A gale of wind from the Southward, a low barometer, and a high spring-tide concurring, cause damage and inundations on the Southern coast of Cornwall and Devon. From the form of the Bristol Channel, and the absence of a free passage for the waters, such as exists at the Straits of Dover in the English Channel, Westerly winds force up and sustain a great body of water, thereby raising the sea above the mean level several feet. It appears from an account of the great storm of the 26th November 1703, that the tide flowed over the top of Chepstow bridge, inundating all the low lands on both sides of the Severn, washing away farmyards, drowning cattle, &c. and it is

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* A circumstance connected with this subject, of considerable practical value, has been noticed by Mr. **Walker** during his long-continued observations. He has found that changes in the height of the water's surface, resulting from changes in the pressure of the atmosphere, are often noticed on a good tide-gauge *before* the barometer gives notice of any change. Perhaps something may be due in these cases observed by Mr. **Walker** to the friction of the mercury in the barometer-tube, as it is well known that in taking careful barometrical observations it is necessary to tap the instrument frequently and carefully, to obtain the measure of the true weight of the atmosphere at a given time and place. The practical value of the observation is, however, not the less, be the cause of the phenomenon what it may; for if tide gauges at important dockyards show that a sudden change of sea-level has taken place, indicative of suddenly decreased atmospheric weight, before the barometer has given notice of the same change, all that time which elapses between the notices given by the tide-gauge and barometer is so much gained; and those engaged with shipping know the value of even a few minutes before the burst of an approaching hurricane.

worthy of remark, that the barometer is recorded to have then fallen lower than had ever been previously noticed."*

"It will be obvious that while in a hurricane, such as that of November 1836, noticed by Mr. **Walker**, the level of the sea was raised on the South coast of Cornwall and Devon, *it was also depressed on the North coast of those counties*; so that the difference in the sea-level on the two coasts thus caused, would be the sum of elevation and depression produced on each coast respectively."

169. **The Storm-currents** we assume to be a succession of currents analogous to those which we see round the sides of a whirlpool, and to be produced by the forces of the various winds blowing round in the area of the storm (Cyclone).

It will be seen then, that the Storm-wave and Storm-current give rise in every storm to two sets of forces (currents) independent of that of the wind, acting upon a ship; the one carrying her bodily onward on the track of the storm, and the other drifting her round the circumference of that part of the storm circle in which she may be.

On that side of the Storm circle where the winds agree, or nearly so, with the track of the storm, both may be acting together; on the opposite side they will counteract each other, and on other parts of the circumference, they will act more or less across, or diagonally: thus, taking, as the simplest case, and one nearly that of Madras Roads, a storm travelling from East to West, and striking upon a Coast running North and South, its centre passing over Pondicherry, we should have then, for all ships in the offing, one current, 'the Storm Wave' carrying them directly on shore, with greater or less velocity, as they were nearer or farther from the centre? and other currents, 'the Storm Currents' varying in their direction according to the situation of each ship in the Storm Circle, but always agreeing pretty nearly with the direction of the wind.

The current of the Storm *wave* then is setting due West: but that of the Storm *current* West on the North side of the Storm circle, and due *East* at its South side; South at its Western edge, and North at its Eastern side, and so on in all the intermediate

* Walker, MSS.

directions; and a ship putting to sea from Madras Roads in our supposed case, will be carried right towards the shore by the *Storm-wave*, and to the South-Westward also by the *Storm current;* but if putting to sea from any place to the Southward of Pondicherry; that is on the Southern side of the Storm-circle; she would be carried one way by the Storm-wave, and the opposite one, or partly so, say to the S.E., East, or N.E., by the Storm-current; so that as to mere Westing, the effect of the one would probably neutralise that of the other. The case of ships on that half of the storm, where both forces are against him, should however be borne seriously in mind by the seaman at all times. I have no doubt, that it has very often occasioned the loss of vessels, and I proceed to give some instances showing certainly the existence of this wave and of these currents in various seas, and of their probable effects.

170. **Instances of the Storm-wave and Storm-currents.** Many seamen, and those old and experienced ones too, will say that they have gone through plenty of gales and hurricanes without meeting with *much* or any current, and will be therefore a little doubtful of the importance which I attach to these; or may even suppose my views exaggerated. It may be worth while therefore to consider first how it is that we have so few accounts of them. I take the reasons of this to be,

(a) That *at times* there *is* very little Storm-wave or Storm-current, while, as will be presently shown, they are at times of extraordinary strength. We do not yet know *why* this is so, but there is no doubt of the fact.

(b) That in most merchantmen, and I fear, formerly, even in some Men-of-War, the log is very badly kept, or in the first not even kept at all in severe hurricanes (Cyclones)? When, after a tempest (Cyclone) it is found that the ship is very far out of her reckoning, the observations are taken for a new departure, and the unexpected difference of position set down as excessive drift, (the rate of drift never having perhaps been ascertained by the log throughout the gale) or heave of the sea, or as a *current:* in the usual acceptance of this word to signify any difference between the

log and observation, which the seaman cannot readily account for.*

(c) That sometimes, as before stated, the ship's position in the Storm-circle, is such, that the Storm-wave and Storm-current neutralise each other, and then, though both have been strong, the ship has felt no effect from them; and if another vessel differently situated *has* been carried a long way by them, and the two accounts are compared, the one is thought not to have kept so good a reckoning as the other, or the matter is passed over like all other "very unaccountable things" (and truly till now they were such) by the careless sailor.

(d) That in some situations, as in the Gulf Stream, they occur in the localities of known currents, and if they act in the same direction or "thereabouts" are thought to be merely an increased action from the same cause, and are thus again passed over or set down to it.

(e) Both the Storm-wave and Storm-current appear, like the winds, to be of great force at or near the centres of circular storms, (Cyclones) but to lose this rapidly as the distance increases from the centre; so that while one ship is carried a wonderful distance by the Storm-wave and Storm-current *and* her nearness to the centre—all three acting the same way—another at a greater distance, and on a different side of the circle, experiences very little of this fatal current. So that from all these apparent contradictions, the instances related, though perfectly authentic, have come to be held as utterly exaggerated or inexplicable. Like the histories of stones falling from the heavens, they have been thought mere traveller's tales, because they could not be readily accounted for.

(f) In some cases, and no doubt with some ships more than with others, when vessels are fairly so pressed down by the force of the wind as to be lying with their lee gunwales in the water, and the "lee sea" washing half way up to the weather bulwarks, there is no

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* I am not here writing sarcastically, but seriously. How few ships are there which, even now, duly ascertain and take any account of the local Deviation of their compasses? which may amount with some vessels and various cargoes or armaments, and on certain rhumbs, to as much as one or two points! The effect of all this is set down as *current*.

doubt that they drift much faster to leeward than they suppose; and rarely indeed *can* the log be hove at such times when the seaman is but waiting perhaps for a heavier gust or a deeper lurch to cut away his masts. But in such situations, a stout ship, with a good crew will lie for many hours, particularly if relieved of her topmasts by cutting or carrying away, and it is at such times that the drift by log should be accurately known to ascertain what is really due to the Storm-wave.

(g) And, finally: until public attention is properly directed to this and indeed all other parts of our subject, and public means adopted to insure the collection and digestion of the vast masses of knowledge which, in the shape of detached facts are now, as heretofore, annually lost to science and to humanity, there must always be hundreds, if not thousands of notices in existence, but beyond the reach of the labourers in the cause.

The foregoing will account, I hope, to the oldest seaman for the want, hitherto, of definite information, and the frequent absence of any notice of such effects as those we have assumed to arise, frequently if not always, from the action of rotatory storms (Cyclones).

171. In the West Indies Colonel **Reid,** (p. 523, 2nd Ed.) says in reference to the Gulf Stream:

"After the storm of September 1839, Mr. **Hurst,** of the brigantine *Queen Victoria*, (whose place is marked in the chart), found the current of the Gulf-Stream neutralized; and the same commander, on another occasion found the current running to the Westward, a fact corroborated by other printed statements at the time.

"The storm of 1839, when crossing the Gulf-Stream, was probably five hundred miles in diameter, and a diminished pressure, amounting to a fifteenth part of the atmosphere, at the centre of a moving circle of this extent, seems adequate either to arrest or to accelerate existing currents, or create new ones."

172. Mr. **Redfield** in his last Memoir, American Journal, of Science and Arts, 2nd series, vol. II. gives p. 169, the abridged log of the barque *Zaida* off the West and N.W. part of the Island of Cuba, in the great Cuba hurricane (Cyclone) of October 1844; and at the conclusion says,

"Captain **Chapman** states that during the gale the Gulf-Stream current off Cuba *had become changed in its course*, drifting the *Zaida* rapidly to the Westward, so that on the morning of the 7th he found himself off Cape Catoche in Long. 86° 40′. On the 11th October at 3 P. M. he picked up the two survivors of the *Saratoga* off Cape Florida, in Lat. 25° 40′. This position of the piece of wreck appears to show also the extraordinary check of the surface current of the Florida stream, for these men were drifted off the bank of Bahama as early as the 7th."

173. In a paper published by Dr. **Peyssonnel** (Phil. Trans. for 1756), on the currents of the Antilles, he speaks of what he calls Counter tides, which he expressly says were very violent at Martinique and the neighbouring islands when they had storms or hurricanes; and again that when St. Eustace (St. Enstatius) was ruined by a dreadful hurricane "coming in a contrary course," on the 1st November, we had here (at Guadaloupe) the most violent counter-tides. He gives also some details, but not sufficiently precise for our purpose, and some of them apparently erroneous or exaggerated, but there can be no doubt that he refers in most cases to true storm-waves and currents, and I trust that attention will be given to this curious but highly interesting part of the phœnomena of storms in those quarters.

174. In Mr. **Redfield's** paper on the Mexican "Norther" and Bermuda Gale of Oct. 1842, (Amer. Jour. Science of 1846, p. 157), it is mentioned, in Report No. 22, from Cedar Keys, Coast of Florida, Lat. 29° 9′ Long. 82° 56′ West, which was a little to the Northward of the centre of the storm's (Cyclone's) path, that "the water is stated to have risen 20 feet above low-water mark, and within 6 feet of covering the island." About 5 or 6 feet are to be allowed for the tide here, so that it was evidently a very remarkable rise. Mr. **Redfield** attributes it to the effects of the Southerly wind on the right side of the gale. The barometer is not given.

175. While this work is passing through the press, we receive a newspaper account of the hurricane (Cyclone) and inundation at Grand Cayman in October 1846. No positive heights, from which we could deduce the total rise of the sea are given, but we cannot suppose it, by what is said, to have been less than 15 or perhaps 20 feet, and it appears also to have been a true Storm-wave which "having risen

"above the iron-bonud coast about midway the island (Savannah) "flowed through 'Newlands' into the sea on the other side, forming "a kind of rapid entirely impassable in the usual course."

This is exactly what should occur in a small low island lying in the track of any part of a Storm-wave.

176. In the Southern Indian Ocean. The brig *Charles Heddle* to which I have before alluded (p. 71) between the 22nd and 27th of February, scudded *round and round* on the track of a hurricane (Cyclone) for five successive days! When her log was carefully worked up, it was found that by it alone her course and distance was *North* 42° East, 111 miles, while by good latitudes and chronometer sights, before and after the storm (Cyclone) she had really made good in these few days a course and distance by observation of *South* 55° West, 366 miles, giving here thus a current (the Storm-wave) of South 52° West, 476 miles, or in round numbers (which would require 480 miles) four miles per hour for the 120 hours, or five days. The average distance from the centre at which she scudded round it, is about 42½ miles; the greatest being 62 miles and the last 25 miles. There is no doubt of the carefulness and authenticity of this vessel's log, which was procured for me by the Master Attendant at the Mauritius, Capt. Royer, and of her position being nearly correct, for she had just left the Mauritius and returned to it after the hurricane, (Cyclone), it is thus clearly an unquestionable instance of the Storm-wave.

177. Another has just occurred in the case of the ship *Tudor*, Captain **M. T. Lay**, which vessel, bound to Calcutta, in Nov. 1846, encountered a severe hurricane (Cyclone) in Lat. 13° South, Long. 83° East and hove to, to allow the centre to pass to the Northward of her, for 16 hours. Captain **Lay** had excellent sights before and after the storm (Cyclone) and estimates his drift at 56 miles during the time he was hove to; yet he found that he had been set 133 miles to the West of his dead reckoning, and his estimate would still leave 77 miles of drift in the sixteen hours to be accounted for, and this we can only do by supposing both Storm-wave and Storm-current acting together (as the ship was very near the centre, having her barometer down to 29-20), at the rate of nearly 5 miles per hour.

178. On the Coasts of Australia. In the account of the Port Essington hurricane (Cyclone) p. 43, § 58 already alluded to, it is stated that the sea rose ten feet and a half by measurement above the usual high-water mark. This storm (Cyclone) was one of great intensity, though of small extent, and its centre did not pass, it appears, exactly over the settlement, but it is quite probable that the rise was a true Storm-wave.

179. There is also a very clear and remarkable account of the Storm-Currents in the Nautical Magazine for 1841, p. 725, on the Western Coast of Australia, by Commander **Wickham**, of H. M. S. *Beagle* who says,

"There are other never-failing indications of a Northerly wind, (with which the N.W. storms begin on the coast), such as the change of the current, which owing to the prevailing Southerly winds usually set to the Northward, but run strong to the Southward during Northerly winds, *frequently* preceding them, and giving more timely notice than the barometer."

Again, after describing a N.W. gale, and these seem to be truly rotatory (Cyclones), for "they commence at N.N.E., and invariably veer to the Westward, and between W.N.W. and W.S.W. blow the hardest," he says, p. 725 N. M.

"The change of current did not precede the wind, but changed with it. When the gale was strong from N.W. and W.N.W., the current ran a knot an hour to the S.E., and when the wind changed to S.W. it ran with the same velocity to the N.E."

He also describes a Storm-wave, or rise of the water, p. 722.

"A rising of the water is likewise a certain prognostic of a Northerly wind, and has been invariably noticed at Swan River to precede all gales from that quarter: this of course can only be observed while at anchor on the coast."

It is evident that the "rise of water" is the effect of the distant Storm-wave, and that it at once explains the current. As observations are collected, we shall doubtless find on this, as on more peopled coasts, the points where the centre of the storms (Cyclones) come to land, to be those where the Storm-waves and currents are most

strongly felt. The sets of current along the Coromandel Coast are very well known, and at the approach of the hurricanes (Cyclones) are often very strong.

180. In the Bay of Bengal, I have been enable to ascertain, *certainly*, by means of circular letters and queries addressed to the commanders of the Pilot and Light vessels stationed at the Sand Heads, that at the approach of, and during gales from the Eastward, or hurricanes (Cyclones), a heavy set of from three to five knots an hour from the Eastward is experienced. If the Storm Card be laid down at the head of the Bay of Bengal, and moved across it from East to West, or up from the S.W. to the N.E. which are the usual tracks, it will be easily seen how the weaker of these currents are Storm-currents, and the stronger ones probably Storm *waves*, as occurring when the centres pass near to, or over the Sand Heads, or further up, which they not unfrequently do. Nothing, indeed, is so common, as for ships which have put to sea from the Floating Light to gain an offing, to find themselves most unexpectedly, and after large allowance for their drift, in shoal water on the edge of the reef off Point Palmiras; and Arab and other foreign vessels, as well as not unfrequently English ones, unacquainted with this peculiar current in bad weather, are often wrecked thereabouts.

181. In the China Sea. We have several notices here of undoubted authenticity, being logs and reports from the Captains of the East India Company's China ships, who were all skilful navigators and men far above any suspicion of exaggerated or careless reports to the Court of Directors, as they were liable to be very strictly called upon and heavily fined in cases of delay, or damage, or misrepresentation, which last would always be known by the evidence of their numerous officers. Hence these documents are of as great value as the logs of men-of-war, and as the instances are very extraordinary, it is important that the reader should know that they are quite trustworthy before he reasons on them.

The following are instances, in this sea taken mostly from my Sixth Memoir.

182. **Horsburgh**, who had great personal experience, and who made also extensive enquiries amongst those who were well acquainted

with the China sea, says p. 289, speaking of the tyfoons between the Grand Ladrone and Hainam, as coming down from the E.N.E. (such as our tracks I. IV. V. and XI. on chart IV.), upon ships bound to China* after describing the changes and shifts of wind, from N.W. and North to N.E. and East, S.E. and South, says in conclusion, "The current at such times runs strong to the Westward," and again, "When a gale happens to blow out of the Gulf of Tonking from North Westward and Westward, the current at the same time sets generally to the S.W. or Southward, in the vicinity of the Paracels, or where these gales are experienced." With the Card and with attention to what has been said in the preceding paragraphs, it will be seen at once why this difference is made. In the first instance, a ship crossing the South Western quadrants of a tyfoon (Cyclone), if as we have described, she does so rapidly with a fair wind and then heaves to at, or close to the centre, finds the Storm-wave and Storm-currents both setting her the same way for the greater part of the hurricane (Cyclone), while in the latter case as she remains entirely in the Southern quadrants of it, the storm *wave* is carrying her to the S.W., and the storm *current* to the S.E. so that between the two and her drift, she may find the *current* Southerly and South Westerly, and sometimes no doubt South Easterly.

183. In July 1780, the H. C. ship *London*, Captain **Webb**, was driven at four in the afternoon from her anchors in Macao Roads,† and was obliged to put to sea with an E.N.E. gale. She stood out with all the sail she could carry, and at six had the Grand Ladrone bearing N.E. At eight she was in 20 fathoms water, and the wind "flew round" to S.E., and at midnight to South. At day-light (or say about 7 A. M. in such weather,) they had driven close in with the land, and were saved by their sheet anchor.

"The drift we made was amazing. I imagined it at first only about fifty miles, but to my astonishment, when the gale was over, I found myself as low down as Haynan, within the Easternmost‡ island."

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* They never pursue this route if bound from China homeward.

† Jour. Asiatic Society, Vol. XI.

‡ Printed *Westernmost* in original, but evidently an error.

We may suppose Capt. **Webb** to have made the largest allowance he could for his drift before so reporting, yet this ship must have been drifted *by the Storm-wave alone,* for the wind was at S.E. and South, which would have drifted her to the N.W. and North, upwards of 125 miles in thirteen hours, (for the Taya Islands bear about W.S.W. 175 miles from her position at 6 P. M., and Captain **Webb** allows 50 miles, or nearly four miles per hour for the drift,) or nearly ten miles an hour; and in a W.S.W. direction or directly with the track of the tyfoon (Cyclone). Making any allowance we please for her having been perhaps unmanageable, and at times before the wind, though her masts were all standing, and she was well prepared for the tempest (Cyclone), having her topgallant-masts on deck, &c.; still this is almost incredible, were it not borne out by other strong instances.

184. In September 1809, the H. C. ship *Scaleby Castle* was drifted 111 miles to the Westward of her supposed position, (no doubt after every consideration and allowance made) in 48 hours, or 2-3 miles per hour. This ship was not in the centre of her tyfoon (Cyclone) though not far from it; her barometer falling to 28.30. She was on the Northern side of the Storm-circle, and thus her excessive drift was probably rather a Storm *current* only.

185. The H. C. S. *Castle Huntley,* 25th to 27th September 1826, was drifted in a tyfoon (Cyclone) which was travelling from the South 77° East to the North 77° West, and this while she was at perhaps 70 miles from its centre, at least 290 miles* in 46 hours, or nearly 5 miles an hour. If we allow the ship's drift to be three miles, there still remains two per hour for the Storm-current.

We have thus for this sea clear and undoubted proofs of Storm-waves and Storm-currents of great intensity and considerable duration, and when we recollect that the China tyfoons often bring with them awful inundations on the coasts,† we can have no doubt that

* Mr. **Wise**, an officer of the ship, estimates it at "upwards of 300 miles under bare poles."

† To the Westward of Canton, where there are no large rivers of which the streams, being dammed up by the wind and swollen by the rains, might produce them.

the phænomenon exists much in the form which I have described it. The close relation of the inundations to the Storm-wave, we shall presently shew. A careful consideration of our Chart No. IV. will show how a tyfoon (Cyclone) coming in, perhaps at least from the Marianas, Bonin Islands, or Loo Choos, if not from farther Eastward, may sweep the Southern coasts of China with a huge wave of power and extent sufficient to produce these extraordinary effects.

186. I have not adverted here to the Northerly, North Westerly, and North Easterly currents, described by Major **Rennell, Kelly** and others, and commented upon by **Purdy** in his able Memoir on the Chart of the Atlantic, as common and undoubtedly existing at the entrance of the British Channel, for the simple reason that I consider the whole of the data on which they are calculated as uncertain, and probably erroneous. Currents there are no doubt, and strong and most dangerous ones too, even in comparatively fine weather, but as before observed (p. 132, Note.) in how many merchantmen in the present day, is the DEVIATION of the compasses duly ascertained, studied, applied to correct the courses, and watched to see if any alteration occurs in it? Until we know what was the Deviation on board of ships said to experience currents in fine weather almost all the "*log book currents*" must be distrusted. Where ships are hove to in a gale, and a due allowance is made for their drift, or in the rare cases of a perfect calm where the current can be tried, we may reasonably allow that the current has existed; but when the course on a considerable distance is really uncertain to 5, 10, or even 20 degrees, we should waste time, had we even the details before us, to endeavour to analyse these data for our purpose, which is to demonstrate if we can; or at all events to put the mariner on his guard against; the *temporary* currents produced by storms.*

* After the loss of the *Great Liverpool* Steamer belonging to the Peninsular and Oriental Steam Navigation Company on Cape Finisterre, in 1846, a Committee appointed to investigate the circumstance, reported it as owing to an "unusual indraught," and the P. and O. Company issued an order to their commanders that, at night and in thick weather they were to give Cape

187. The Western entrance to Bass' Straits is also a locality in which what we have said of the Coast of China, (all things being reversed here as being in the Southern hemisphere, and in a high Southern latitude) might theoretically be expected to hold good; and if the reader will first refer to what has been said of the tracks of storms hereabouts, (p. 43 § 59) and then placing his Horn Card on a Chart move it along from the West or W.S.W., to the Eastward, he will see at once that there are good grounds for supposing at least, that with the heavy Westerly or North Westerly gales forming the North and N.W. quadrants of a circular storm (Cyclone), which has travelled in

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Finisterre (and strange to say Ushant was not alluded to!) a berth of twenty miles. In an article published in the Calcutta '*Englishman*,' I commented upon this order as follows, after explaining what the Storm-wave and Storm-currents were,

"The rule given by the Directors of the P. and O. Company is, that at night and in thick weather, twenty miles berth is to be allowed to Cape Finisterre.

"Now, putting aside temptation to 'turn the corner sharp,' and supposing fully twenty miles to be always allowed, we shall show that instances may arise in which this is only half enough!

"The great storms of the Atlantic are, there is no doubt, very often, if not always, revolving storms of from 500 to 1000 miles in diameter, and travelling from the track of the Gulf-stream past the Bermudas and Azores to the coasts of Spain and Portugal, the Bay of Biscay, the Channel, or the Northern Ocean. They sometimes preserve their full size, and then *appear* to be gales blowing in nearly one direction only—that is, veering but very slowly—and sometimes contract in size, when their duration is shorter.

"When the first case happens, there is probably little or no Storm-wave, or currents on the exterior borders of the storm; but as it approaches or passes over a spot, these may be felt moderately and even strongly. In the case of the *Great Liverpool*, if we take it that the Westerly to S.S. Westerly gales were the Eastern and Southern quadrants of an Atlantic revolving gale, and the insets the currents, her case is clear enough: but we are told that, in future, a berth of twenty miles is to be given to Cape Finisterre. In ordinary cases, of a moderate current, this may be enough; but taking the case where the centre of a storm passes near, and to the Northward of that point, the Storm-wave and Storm-currents together may induce a set of at least three miles an hour. We will put it at two only, and allow the steamer to have run up from a sight of the Burlings. It is clear that to put her twenty miles wrong she needs only ten hours run in this Westerly set, the ten hours of an ordinary night in those latitudes, and (here lies the mischief) the commanders

from the Southern Indian Ocean, strong Storm-currents or a strong Storm-wave, or both acting the same way, might occur. And so it notoriously proves, for the repeated and dreadful wrecks of Emigrant ships off the N.W. point of Van Dieman's Land, with the "narrow escapes" of many, which have just seen their danger in time, are indubitable proofs of it. The following, which is abridged from a newspaper notice, is a direct instance, and it appears to be written by one who understood something of nautical matters.

"As to the Western entrance into Bass's Straits, the writer of this has reason to be glad that Providence preserved him and the ship in which he sailed from England from the fate of the *Cataraqui*;* as she was in very nearly the same latitude and longitude, and during a dark stormy night, in soundings which, compared with Captain **Stokes'** Chart, show her to have passed close

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may think that they fully take precaution enough if they give the Cape the 20 miles required. If the currents should unfortunately run stronger, or the thick weather lengthen out the nights, or render bearings or distances uncertain or impossible, the chances of another misfortune are much augmented.

"Our view, then, is, that the rule laid down by the P. and O. Company should rather have stood thus:

"And the Board further direct that the ships of the Company, on the voy-
"age between England and Gibraltar, both outwards and homewards, and
"especially with reference to the extraordinary inset noted above, and the pos-
"sibility that in cases where the focus of a revolving storm from the Atlantic
"may be passing near Cape Finisterre, this dangerous inset may be much
"augmented, strictly enjoin that, when passing this point and the latitude of
"Ushant, if Southerly, S. Westerly, or Westerly gales prevail, or have recently
"prevailed, and especially if the barometer should have fallen, that a wide
"berth of from thirty to forty miles or more may be given in the night and in
"thick weather."

"We submit with all deference that this rule comes much nearer to the present state of nautical science than the one given. We are aware that experienced seamen usually say, and we believe the "Directories," and "Pilots" also, that when a North Easterly storm is blowing out of the Chops of the Channel and Bay of Biscay, there is a strong current along the Coast of Portugal, and round Cape Finisterre. If there is also a Westerly gale, this would be exactly a Storm-current, such as the authors we have quoted infer to exist, and Mr. **Redfield,** indeed, inclines to think with Professor **Dove** of Berlin, that *all* winds blow in circuits; and certainly there is much to confirm these views. At all events, nothing should be risked for

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* Wrecked at the entrance of Bass's Straits with 400 Emigrants on board.

to the Harbinger and Navarin Rocks, on which vessels had been previously wrecked.

"That there is probably a set of some kind off the coast, Westward of Cape Otway, by which ships are carried to the Southward is very probable. Captain **Stokes** does not, however, allude to it. Something of the kind probably occurred to the *Cataraqui*, for Captain **Stokes** ascertained by correspondence with her owners, that the master had his chart on board. When it is considered that the coast slopes down rapidly from the Great Australian Bight to King's Island and the Western side of Tasmania, it is not surprising if there should be under the action of Westerly winds, frequently blowing a heavy gale, a deflection of the current, setting a ship in dark stormy weather out of the proper course; and it is matter of surprise rather than otherwise that but five wrecks (however fatal they may have been) should have taken place off King's Island in twelve years. It is to be hoped that for the future, with lights on Cape Otway and the Kent Group, the navigation of Bass's Strait will be as safe as the British Channel, where it will be recollected, wrecks occur off St. Catherine's, in the Isle of Wight, from a set off from the Channel Islands, as in the case of the *Clarendon* West Indiaman, which was cast ashore on a rocky ledge, despite all the lights from the Lizard to the Needles, during a S.W. October gale, which the writer recollects having been exposed to it, and having lost relatives in the wreck of the ship."—*Sydney Morning Herald, Dec.* 10.

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want of a trifling precaution, which, for two or three steamers in the course of a year may cost an hour or two more of steaming, by making rather a wider circuit past these dangerous points."

I at the same time drew up and addressed to the Lords Commissioners of the Admiralty, a paper of "*Instructions to officers of H. M. Navy, regarding the observations desired on the Storm-wave and Storm-current when in or near soundings, and from the Lat. of Gibraltar to the British Channel*," respectfully suggesting that it might be published, as a means of obtaining some useful data to enable us to ascertain all the conditions of this danger, and offering to analyse the observations. Their Lordships, I am glad to say, have done me the honor to recommend its being printed in the Nautical Almanac, and I trust that all British seamen, at least, will see the great importance of the questions, to them of life or death at times, which may depend on the investigation; and aid me by all the information old or new which they can collect. The Peninsular and Oriental Company in acknowledging my communication, acquiesce on the part of their committee and for themselves, (and they had the best nautical advice in London to consult) in the utility of the suggestion. The sailors must do the rest for themselves by furnishing material.

188. The seaman also adverting to what has been before said that winds may be blowing in true circuits (Cyclones) without rising to the force of a gale or hurricane, should bear in mind that in narrow seas especially, and where perhaps other causes may be acting, *and acting the same way* so that two moderate causes may produce a strong effect, the Storm-wave and Storm-current may also be acting then to a certain extent, and carrying him far out of his reckoning, while he is deprived of observations in dark gloomy weather.

189. The *Nortes* of the Gulf of Mexico may often be of this description, for storms there which are moderate as compared with hurricane forces, may yet be true circular ones (Cyclones), and produce *Nortes*, (Northerly gales) in various parts according to their tracks. One coming into the Gulf from the S.W. or South, or from the Pacific Ocean across Central America, might give a *Norte* on its Western edge, and one coming in like the tracks V. XII. XV. &c. on Chart I. would also give a *Norte* on its Western verge. In the two cases ships would be carried quite different ways by the Storm-wave if it existed, for this would be regulated by the track of the storm.

190. The recent dreadful loss of the Royal Steam Mail Company's Packet ship *Tweed* on the Alacranes, appears to me not improbably a case of the Storm-wave in a moderate gale, as I have just described it.

The following account is given in the *Steam Navigation Gazette*, and *Nautical Standard*, as to wind and weather previous to her striking, from the statements of the first and second officers.

"It appears from the statement I have received, (at a brief interview, immediately on their arrival, with Mr. **Ellison** and Mr. **Onslow**, the first and second officers,) that the unfortunate *Tweed* left Havannah on the evening of the 9th of February for Vera Cruz, with a fresh Southerly breeze, that lasted about ten hours. It soon after became thick, and at midnight on the 10th the wind suddenly shifted to the North, and in a short time it blew a stiff 'Norther,' weather still thick, sun obscured, and no observation. At 3-30 A. M. on the 12th, when the Captain judged the ship was 30 miles to the South of the Alacranes, the look-out on the forecastle cried out 'Breakers a-head.' Captain **Parsons**, who was on deck, hearing them at the same moment, immediately ordered the engines to be stopped and reversed, and the

helm to be put hard a starboard, which order was instantly obeyed, but the fore-sail, fore-trysail, and fore-topsail being set, and a heavy sea running, she forged a-head and struck."

From the Havannah to the Alacranes, the true course and distance is South 84° West 440 miles, though it becomes somewhat curved while running along the Coast of Cuba, but this we will leave out. The vessel seems to have had ten hours run with a Southerly breeze, (under the lee of the coast of Cuba), and then thick weather till midnight on the 10th, when the shift of wind took place, this gives her at let us say nine knots an hour from 6 P. M., on the 9th, 30 hours run or 270 miles, which would bring her about opposite to the middle of the channel between Yucatan and Cuba.

Now placing a Storm Card (even upon our small chart) so as to give the *Tweed* a Northerly wind *(Norte)*, and supposing the storm to have slowly moved up on a course about parallel to our track XV., we can see how the *Tweed* standing across, but nearly along with it, might keep the Northerly winds till 3-30 A. M., of the 12th, or 15½ hours longer, and yet be set up 30 miles to the Northward of her supposed position. The error in position might also, it is true, arise from a small unknown deviation of her compasses, but the account of the weather is distinctly that of a moderate circular storm (Cyclone), and in narrow seas, as before said, the seaman cannot be too careful, or too often recollect that two or more petty causes *acting the same way* may produce a serious amount of error.

Colonel **Reid's** Chart (at p. 399 of his work 2nd Ed.) of the storm which dispersed the Spanish Fleet under Admiral **Solano** in 1780, is exactly one of a hurricane (Cyclone) passing on the track which I describe.

191. **Inundations from the Storm-Wave.** I have shewn the seaman, and I trust satisfactorily, that there exist in many parts of the world, both Storm-waves and Storm-currents, which for him, and while at sea, are to be regarded and calculated upon as currents; and no doubt we shall find, as our knowledge extends, that they exist in other parts, and moreover obtain more accurate knowledge of them everywhere. I now proceed to shew him that there really exists an actual *wave* or elevation of the sea,

as announced theoretically at p. 127, which rolls in upon the land like a huge *wall of water*, as such a supposed wave should do, causing of course dreadful inundations. He may at first suppose that he has little to do with the inundations on land, if he can keep his ship in safety at sea; but lest this objection should occur to any, I answer first, that it is of much importance to *prove* that there is a real lifted wave; and next that this very wave, while it is a source of great danger—for ships have been swept out of docks and rivers by it—is on the other an element of safety, for it has sometimes carried vessels over reefs and banks, so as to land them high and dry, and preserve at least the lives and cargo. Of this the case of the *Briton* and *Runnimede* already alluded to, pp. 39, 75, is a striking example.

192. Col. **Reid** in reference to this says, p. 513, 2nd Edition,

"An anchorage, which would be of sufficient depth in ordinary gales, might prove too shallow during a hurricane, in consequence of the depth of the trough of the sea from the unusual undulations created by such storms. Instances have been here given, when the effect of hurricanes, blowing into a bay, has been to heap up the water within it for a time; so that vessels which have dragged their anchors during such a crisis, have been carried into places whence they could not float after the storm had passed over.

"The opposite consequence may also occur: such as happened to the *Lark*, surveying schooner, when at anchor off the west coast of Andros Island, in the Bahamas, 'Owing to the receding water, that vessel struck heavily from 6 to 8 P. M., on the 6th of September 1838; but floated again on her being raised by the S.E. gale, whilst the wrecking schooner *Favourite*, 68 miles North of the *Lark*, was left completely dry.'"*

But this sort of inundating wave, as will be seen, must not be confounded with that gradual rise of the sea or rivers, which is familiar to our minds, as the "*heaping up*" of the water by the effect of wind, and which always occurs gradually. The wave, of which we shall give instances, is one resembling that which so often accompanies or follows earthquakes. In some cases, indeed, the hurricane (Cyclone) earthquake and inundation have apparently all occurred together!

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* Lieut. Smith's Report, *Nautical Magazine* for January 1839, p. 30.

193. **In the West Indies.** At Savanna La Mar, which was totally destroyed by the first of the two great October hurricanes in 1780, we find that—

"The gale began on 3rd October, from the S.E. at 1 P. M., abating about eight; the sea during this last period exhibited a most awful scene. The waves *swelled* to amazing height, rushed with an impetuosity, not to be described on the land, and in a few minutes determined the fate of all the houses in the bay. About ten, the waters began to abate, and at that time a smart shock of an earthquake was felt. Three ships were carried so far into the morass, that they could never be got off."*

Colonel **Reid** says, referring to other notices of this storm,

"There seems no reason to doubt, from what we now know of the effect caused by hurricanes, that Savanna La Mar was overwhelmed by the accumulated water of the sea raised solely by the power of the wind."

194. In the second great October hurricane of 1780, which began on the 10th October of that year, and committed dreadful ravages at Martinique, we find from a French official report, given p. 344, by Colonel **Reid**, and of which I abridge and translate what is essential to our present subject that (apparently about the time that the centre was passing close to the town of St. Pierre and Fort Royal,

"An awful "*raz de marée*,"† completed the misfortunes under which we were suffering. It destroyed in an instant, upwards of 150 houses on the sea shore, of which thirty or forty were newly built; those behind them had

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* Abridged from the 2nd Edition of Col. **Reid's** Work, p. 297. The account therein is copied from the *Annual Register*.

† Raz (or Ras) de Marée. This word is used by the French to express every sort of sudden swell, or waves, or rollers from the sea, whether occasioned by tides or currents; except the *bores* of rivers which they distinguish by the word *macrée* or *mascaret*. The definitions of "*Raz* or *Ras de marée*" whence no doubt, our word "*Race*" are; "*Ras des Courans* (current races) masses of water which at sea in narrow passages as amongst islands, shoals, rocks or coasts advance with rapidity. Finally "*Ras de marée*" (tide-race) a name given to those swells which, without appearing to be driven by any wind are formed suddenly, increase in a moment, and mark some strange agitation in the

mostly their fronts driven in, and the goods contained in them, almost totally lost. It was with much difficulty that the inhabitants escaped with their lives."

195. At Barbadoes "the sea rose so high as to destroy the forts," and at several other of the Islands the same kind of devastation is alluded to. It will be noted that the hurricane (Cyclone) came up from the S.E., and that Bridgetown and the ports of Martinique alluded to in the foregoing report are on the S.W. and West, or leeward sides of their respective islands, so that the sudden rise of the sea has much more the character of a true elevation of the waters, by the effect of the centre, than of a mere wave or number of waves rolled in upon the land by the horizontal force of the wind, as we see in high spring tides with strong South Westerly and Southerly gales, on low parts of the coast of the South and West of England for instance.

196. In the Bermuda storm of 1839, referred to at p. 27, and which was no doubt a true rotatory one (Cyclone), Colonel **Reid**, p. 449, 2nd Edition says,

"By examination of the South coast of the islands, the sea was found to have risen fully eleven feet higher than the usual tides. It carried boats into fields thirteen feet above the usual high-water mark, and removed several rocks, containing by measurement twenty cubic feet, some of them bearing evidence of having been broken off from the beds on which they rested by

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waters of the ocean," so far **Romme** in his *Dictionaire de la Marine.* At Bourbon and the Mauritius, the heavy rollers which, as in many other places as at Madras and St. Helena, rise suddenly and break with tremendous force, are called by this name of *ras de marée*, though the rise and fall of the *tide* there is very small. Mr. **Thom**, p. 340, in the notes to a French table of Barometric Observations made at Bourbon during the Mauritius hurricane of 1840, has given in it the remark of "*Ras de marée tres fort* from the 7th to the 11th, so that no communication could be held with the shipping." The hurricane (Cyclone) did not extend to Bourbon. A tremendous *ras de marée* is also experienced in the harbour of Port Louis, when hurricanes pass to the Westward of the Island. In January 1844, five vessels at once were thrown on the rocks near the Bell Buoy, where they had anchored, or were close in, endeavouring to get into the harbour.

the surge. On the North and leeward side of the island, and within the chamber ? of the dock-yard, the water was observed to rise two feet and a half higher than the ordinary tides.

"As the weather became fine at Bermuda, and the hurricane proceeded on its course, the Northern reefs of the islands, in their turn, presented a line of white surge from the swell, rolled back by the gale. Vessels as they arrived from the East or the West, reported that they met the wind in conformity with what appears to be a law of nature in these tempests. Thus the *Jane* coming from Baltimore and the Westward, had the wind Northerly; whilst the schooner *Governor Reid*, from England and the Eastward, had the wind Southerly."

It will be noted that here the great rise was on the windward side of the island, and but a small one to leeward; but we may well suppose that over a large extent of reefs and islands like the Bermudas, lying directly in the track of a hurricane (Cyclone), the wave might divide and roll off to the East and West, leaving a comparative hollow or curve on the North side of the islands; an effect which we frequently observe on a small scale, amongst reefs and rocky shores, where the waves rolling in are divided by a ledge or a single rock; a boat riding to the shoreward of which, will *seem* to sink, in her smooth water, lower than the surrounding waves on both sides, though it is really these which are raised above her, and they afterwards unite in the common elevation of the swell a little within her;* the spot at which she is riding being perhaps really elevated, though but a little, above its usual level.

197. Mr. **Redfield** in his first Memoir, published in 1830, describing a storm (Cyclone) of which the centre passed close to New York, says that—

"The gale was from N.E. to East, and then changed to West. More damage was sustained in two hours, than was ever before witnessed in the

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* I write this with a vivid recollection of the very appearance, having been, now above thirty years ago, severely beaten and bruised in swimming off through the surf on a coral reef to help to save a boat under my charge, the two men in which could not, without a third hand, weigh the grapnell, and pull her out in time to round a point of the reef, to get her into a safe berth. It was only after repeated trials, and taking advantage of these smooth hollows, that I could reach her.

city, the wind increasing during the afternoon, and at sunset was a hurricane. *At the time of low water, the wharves were overflowed, the water having risen thirteen feet in one hour.*"

198. In the East Indies, Coringa on the Coromandel Coast, is frequently subject to inundations, from gales blowing from seaward, and the consequent rise of the waters of the river Godavery; but these are gradual, though rapid, rises, and when occasioned by the river the waters are of course fresh, and when by the sea salt. I should mention also, that the tracks of the storms in the middle of the Bay of Bengal, appear to direct themselves very frequently towards this station and that of Cuttack, (see Chart No. III.), probably from their being situated at the mouths of the vallies of two considerable rivers, while the rest of the Coast is, as it were walled with high land at a short distance in the interior.

In December 1789, Coringa was utterly destroyed by a succession of three great waves, which rolled in upon it apparently during a hurricane (Cyclone). **M. De La Place** of the French Frigate *La Favorite*, who collected his account on the spot, (about 1840), says, Vol. I. p. 285 of his voyage,

" Coringa was destroyed in a single day. A frightful phænomenon reduced it to its present state. In the month of December 1789, at the moment when a high tide was at its highest point, and that the N.W. wind blowing with fury, accumulated the waters at the head of the bay, the unfortunate inhabitants of Coringa saw with terror, three monstrous waves coming in from the sea, and following each other at a short distance. The first sweeping every thing on its passage brought several feet of water into the town. The second, augmented these ravages by inundating all the low country, and the third overwhelmed every thing."

The town and twenty thousand of its inhabitants disappeared; vessels at anchor at the mouth of the river, were carried into the plains surrounding Yanaon, which suffered considerably. The sea in retiring left heaps of sand and mud, which rendered all search for the property or bodies, impossible, and shut up the mouth of the river for large ships. The only trace of the ancient town which now remains, is the house of the Master Attendant and the dockyards surrounding it.

In 1839, Coringa was visited by another of these inundations, which by the Collector's Report, (published in my second Memoir, Journal Asiatic Society, Vol. IX. p. 401), much resembled the one above described, to which indeed the old inhabitants seemed to have compared it. There are no accounts of distinct *waves* in this last storm, but the rise of the waters of the sea is described by one writer as *rushing in* with such violence, that "the only houses "remaining at Coringa, are a particular large house and three or "four other brick built houses. More than 20,000 persons are said "to have perished. Vessels were drifted from the docks and rivers, "and a large sloop (of 50 to 150 tons burden), carried four miles "inland."

199. Cuttack and Balasore have also been subjected to these inundations, but one of the most frightful of them in recent times, occurred in May 1823, along the Northern shore of Cuttack from Point Palmiras to Kedgeree.

A newspaper correspondent of the *Bengal Hurkaru*, writing from the spot, thinks the high wind not a sufficient cause, but that there might also have been an earthquake,* but as I have traced the hurricane (Cyclone) in from sea at least for two days, (track G. Chart III.), I see no reason to doubt its being a Storm-wave. It is said in these notes that—

"All the Natives agree in asserting, that the sudden flood consisted of three great waves only, and that these occurred in the short period of one minute, the last wave rising about 9 feet above the highest embankment,† and committing, of course, the most awful mischief in its progress. Upwards of 600 native villages are stated to have been destroyed."

In October 1831, on about the same parts of the coast, another storm inundation and wave occurred. In an official report, it is stated, that the sea came in 'in a tremendous wave.'

200. In 1822, an awful inundation took place at the stations of Burrisal and Backergunge, at the mouth of the Megna; but here though

* None of the accounts allude even remotely to any shock, and it would have been probably felt at Calcutta where there was no storm.

† The embankments are probably not less than from 10 to 15 feet high.

50,000 human beings are said to have perished, the rise of the waters was gradual, and the strength of the inundation is described as coming in with the spring tides. This storm too, which I have accurately traced, as well as the former one, moved very slowly; about 53 miles in the 24 hours, which may account for its not bringing so heavy a wave with it. See p. 157 where more details are given. We have also on the Coasts of China, and even from the islands of Hainam and Formosa, frequent accounts of these tremendous inundations, accompanying their tyfoons; and as there are no large rivers West of the Canton River, there seems no reason to doubt, that these are frequently Storm-waves, especially from the Tyfoons (Cyclones) which travel up from the S.E., as will be seen on our Chart IV.

201. Enough then will have been said to shew the mariner, I think, that the wave really exists in many cases, and is therefore a danger to be borne in mind and provided against. I have not alluded to the well-known instances of our sudden rises of tide, and even true inundations (as at St. Petersburgh)* in Europe, because these are probably more frequently the joint effects of tides and the driving up of waters by the wind, than the kind of *disk* or umbel, or pot-lid-shaped rising of the waters of the ocean, which we assume to be the true Storm-wave. It is in fact at times difficult so to separate the various causes; which *may* frequently all act together, and all the same way; as to say where the one ends and the

* The St. Petersburgh inundation of November 1824, appears certainly to have been the effect of a storm, but whether of a true storm-wave at, or near, the centre of a circular storm (Cyclone) seems doubtful. At least I have not access to any documents which would shew it to be clearly such, though its progression is clearly shewn from the S.W. to the N.E. being a violent storm on the Coasts of England and Holland on the 15th from the N.W. and W. crossing the North Sea, Norway and Sweden, where whole forests are said to have been prostrated by it, and both in Sweden and Norway *sudden* rises of waters are noticed. At St. Petersburgh however on the 19th in the morning the waters of the Gulf of Finland drove up those of the Neva so rapidly that *in less than five minutes* the whole city was inundated, and the country for miles around, causing a frightful destruction of life and property. The rise of the water at Cronstadt is stated to have been 14 feet. Twelve sail of the line and four frigates are said to have been driven on shore.

other begins. If we could meet with an instance in which the wave rolled in during the passage of the *calm* centre of a hurricane (Cyclone) that would be so far a proof that we might exclude from that instance all the other causes, as tides, wind, &c., and affirm of it then that it was purely the Storm-wave or the effect of an earthquake; but as yet, and from the frightful confusion which these calamities no doubt create, we have no accurate accounts of this kind.

202. **Pyramidal and cross seas.** If the seaman will take both Storm Cards, and reversing one of them so as to have both sets of the wind-arrows pointing the same way, place the one upon the other, upon a sheet of paper, he will then see that *a perfectly stationary* hurricane (Cyclone) would be raising a sea which he might represent by so many rays towards the centre, and which therefore has wider intervals (i. e. is a *longer* sea) at the outer part of the vortex than towards the centre, where each wave must interfere with the other.

If he will now suppose his hurricane moving on upon any track he pleases, and slide his upper Card gradually forward in that direction, he will see that it is only the front part of every hurricane which gets "fresh sea" to act upon,* and that every successive wave of the following part passes over and crosses in a thousand more ways even than those shown by the circles, the sea formerly left by the front portions of the storm.

This is bad enough already: but if he will suppose moreover that there may be a gradual incurving of the wind arrows, to at least as much as two points at the centre, and then the wind blowing with such fury that nothing can resist its force, he will begin to suspect that what has been written and said of the pyramidal sea of a China tyfoon, or Mauritius hurricane, and sometimes of the West Indian ones may be no exaggeration†, and the more if he adds to all this

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* We may suppose too, that, as often occurs, it comes upon a tract of sea where only calms and light winds with "long heavy swells" have prevailed for some days.

† If he will look at the rose engine-turning so common on the back of watch cases, he will understand how every little boss there might represent a sea worked up by the infinite crossings of the forces acting on the waters.

the certainty that, at and near the centre the sea may be raised in a disk or umbel of two feet above the general level by a fall of the barometer, shewing the atmospheric pressure to be diminished so as to compel that rise* by the pressure of the surrounding ocean.

When the sailor has duly considered these facts and allowed them to be possible, he may then, though before incredulous, believe some of the following extracts, and think it worth while to attend to our rules for avoiding such predicaments.

203. Lieut. **Archer** in his capital account of the loss of the *Phœnix* frigate, re-published by Col. **Reid**, p. 308, says:

"Who can attempt to describe the appearance of things upon deck! If I was to write for ever I could not give you an idea of it—a total darkness all above, the sea on fire, running as it were in Alps, or Peaks of Teneriffe (mountains are too common an idea); the wind roaring louder than thunder (absolutely no flight of imagination); the whole made more terrible, if possible, by a very uncommon kind of blue lightning."

204. **Horsburgh** says of the Tyfoons (Cyclones) in the China seas, that they are —

"Frequently blowing with inconceivable fury, and raising the sea in turbulent pyramids which impinge violently against each other."

205. Mr. **Thom**, p. 15, speaking from the log of the *Robin Gray*, in the Rodrigues' hurricane, says:

"It is the sea however, which is most to be dreaded in rotating gales. It is described as having been a tremendous, cross, confused, outrageous sea, raised in pyramidal heaps by the wind from every point of the compass, and has been compared to the surf breaking on a reef of rocks. In fact it was 'such a sea as gave a ship no chance.' Near the centre of the hurricane a ship is always unmanageable, even if she has not lost masts or rudder; the lulls and terrific gusts, which follow one another in quick succession, are alone sufficient for this, but when we take into consideration the fierce conflict of raging waters, it is only wonderful how a vessel can live through such an encounter."

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* See p. 128, and Part V. at the Section on the barometer.

206. Capt. **Rundle** of the ship *Fattle Rozack*, whose able and scientific log* I printed at length in my Eleventh Memoir, Journal Asiatic Society, Volume XIV. has given in it some remarks on the sea, in a hurricane (Cyclone) and at the approach of one, which are highly illustrative of what this sea is. The storm (Cyclone) of which the Memoir treats, was one in the Southern Indian Ocean, and is the storm track to which I have alluded, p. 35. Its track is that marked VIII. on our Chart, and it is also alluded to at p. 59.

At the approach of the hurricane (Cyclone) Capt. **Rundle** says—

"I find barometer considerably fallen, with an exceeding long swell from the Southward, and at 7 a high N.N.W. sea meeting the Southerly swell created an exceedingly turbulent sea. In the squalls the sea has a strange appearance, the two seas dashing their crests against each other shoot up to a surprising height, and being caught by the West wind, it is driven in dense foam as high as our tops. The whole horizon has the appearance of ponderous breakers."

When involved in the hurricane (Cyclone) he says—

"P. M., wind N.E. tremendous squalls blowing with inconceivable fury. The sea rising in huge pyramids yet having no velocity, but rising and falling like a boiling cauldron. I have never seen the like before. I was in the height of the terrible hurricane of September 1834, in the West Indies, I have been in a tyfoon in the China sea, in gales off Cape Horn, the Cape of Good Hope and New Holland, but never saw such a confused and strange sea. I have seen much higher seas, and I am sure wind heavier, but then the sea was regular and the wind steadier.

"Noon, blowing with inconceivable fury at times, with the sea I think more agitated and confused than ever; rising up in monstrous heaps, and falling down again without running in any direction. Noon, laid to again."

207. So violent and remarkable are these seas, that repeated instances have occurred, in which ships running or bearing up, so as to cross the track of a storm (Cyclone) soon after the centre has

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* A pattern for every sailor who loves his profession, and has the interest of his country, his owners or his own at heart. With few hundred such observers afloat, and access to their observations, we should be soon able to track and define the laws for storms all over the world.

passed, have found the sea still so violent in comparison with the force of the wind, and withal so irregular, that they have been in great danger of losing their masts. H. M. S. *Serpent*, with 2½ millions of Dollars on board, the last instalment of the China Treaty money, hove to, as related in p. 33, to avoid a small but severe hurricane in 27° South, 64° East, and when she bore up again crossed the track of the storm (Cyclone). Commander **Nevill** says, "When the barometer rose to 29.80, I wore and bore up, coming into a dreadfully confused sea, where the centre of this turning gale must have passed. For nearly 24 hours I thought I should have rolled my masts away, but by getting up runners and tackles for the lower masts and preventer shrouds for the topmasts previously fitted, I did not lose a spar." A like instance also occurred in the *Golconda's* hurricane in the China sea (see p. 115) to the *Thetis* of London.

Many more such extracts might be given, for they occur very frequently, but these will no doubt suffice to our purpose, which is to show that the best built, and best found, and best managed ship can rarely pass through the centre of a hurricane (Cyclone) without damage, and probably of a serious kind, if it be only that of the straining and tearing of three years in six hours.

208. **Swell felt at a distance from Storms.** I have adverted in a preceding section of this part, to the swell felt on shores and in harbours, such as rollers, surfs, *ras-de-marée*, &c., at the approach of hurricanes (Cyclones), and these are evidence enough that the swell often precedes the gale for a great distance, sometimes, indeed, for as much as 24 hours.

In truth, sailors want no examples of this; but it may be as well to advert here to the fact, that in circular storms (Cyclones) of considerable extent and violence, the swell is often felt as a double one, namely, one preceding the track mixed with one such as the wind at the Cyclone point (see p. 70) of the ordinary storm would give. Thus, if we suppose that side of a storm (Cyclone) to be advancing towards us, which has the wind at South, as in the Northern Atlantic, the wind alone, if a straight-lined wind (see p. 7) would give an East and West line of sea, or what we call a sea from the Southward, but as the storm is advancing to the East, *it* is also

perhaps driving a sea before it in North and South lines, or a sea from the Westward. At a great distance the two forces will give probably "a confused sea from the South Westward," but nearer the two seas may often be clearly distinguished, and are capital indications.* The position and run of the ship, with the average tracks, and the laws of rotation which have been previously explained, and his barometer will show the seaman in most cases when the cross sea is that of an approaching or passing tempest, and when it is that left by one already past, but which he is overtaking.

209. Captain **Blay** of the brig *Standard*, an extract from whose log in the Bermuda Storm (Cyclone) of 1839, (track A on our Chart No. I.) is given, says in his remarks p. 451 of Col. **Reid's** work,

"I remark that I have experienced several hurricanes at sea, and have invariably found, that by observing strict attention to the set of the swell previous to the commencement, and even after, a tolerable correct idea may be formed of the direction the wind is likely to take.

"I particularly noticed this in the last two which I experienced; and on the 2nd September 1838, in a hurricane that commenced at E.N.E. although the sea when I first hove to, set from that quarter, I found it afterwards altered its direction, and came from S.E., and for sometime before the wind shifted to that point.

"I felt so confident from that circumstance that I should have the hardest of the storm from that quarter, that I continued to lay to on the starboard tack, well knowing that when the wind shifted, I should head the sea much better, and consequently the vessel would lie safer.

"In the storm of the 12th September last, although the sky looked much more dismal in the S.E. than any other direction, the swell gave no indication of the wind coming from that quarter; as it set constantly from the Northward."

210. **Noise of Storms.** There appears no reason to doubt, and I have myself experienced it in one case at sea, and in another on shore,

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* See at p. 155, Captain **Rundle's** clear descriptions of these crossing seas. Such phænomena must frequently occur, and those who will read the quotation from Lord **Bacon** which I have placed on the title page, will understand why it is, now at least, desirable that they should be always noted.

that both at the commencement and at the passage of the centres of violent hurricanes (Cyclones) peculiar noises are heard. At the commencement the wind sometimes rises and falls with a moaning noise like that heard in old houses in Europe on winter nights, and this in situations both near and far from the land, and independent of the noise made by the wind in the rigging. Capt. **Rundle*** who had not seen my Horn Book of Storms for the Indian and China sea in which I first described it, at the time he wrote, exactly describes it in the following, almost incidental, remark in his notes : " I do not like this gloomy weather with wind lulling and then coming on again *with a moaning noise;* there either has been or will be bad weather." In the summary appended to the Memoir from which this is extracted, I have in addition to the description of the noise given above, said that in England,—

" We attribute it to the noise of the wind in the chimneys, or amongst the trees ; or on board a ship to the rigging: yet here there can be no doubt of its being distinctly heard at sea as the " roaring and screaming" of the wind in a tyfoon or hurricane certainly is. My present theory to account for it is this. I suppose the storm to be really formed and to be " roaring and screaming" at, say 200 miles distance, and that the noise, if not conveyed directly by the wind, may be so reflectively from the clouds, as in the case of thunder-claps. A noise is known on some parts of the Coasts of England by the name of " the calling of the sea" as occurring in fine weather, and announcing a storm, and also in mountainous countries. All these may be connected, and seamen may render great service to science and to themselves by noting these curious phænomena."

The instance in which it occurred with me on shore, very remarkably, was in the Calcutta hurricane (Cyclone) of June 1842, which forms the subject of my Seventh Memoir.†

On the morning of the day on which the centre passed Calcutta, I have noted,—

At daylight " wind rising and falling."

Between daylight and 10 A. M. " Wind rising and falling very remarkably at varying intervals of 15, 17, and 5 minutes, with the peculiar moaning noise which accompanies high and variable winds."

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* See VIII. Memoir, Journal Asiatic Society, Vol. XII.

† Journal Asiatic Society, Vol. XI.

211. I have also met with logs in which this noise has been noticed; Col. **Reid** mentions, p. 36, that amongst the signs noticed at Barbadoes by Mr. **Gittens** in 1831, who appears to have been a careful observer, and well acquainted with the signs of an approaching hurricane (Cyclone) was, "2ndly. The distant roar of the elements, as of winds rushing through a hollow vault."

In the log of the ship *Ida*, given by Col. **Reid**, (p. 102), it is remarked at the onset of a hurricane (Cyclone) as follows:

"Fresh gales and squally weather; at 4, handed the fore-top-sail, and fore-sail; *at intervals the wind came in gusts then suddenly dying away, and continued so for four hours.*"

No doubt the moaning noise might have been distinguished here by an observant person if his attention had been directed to the subject.

212. **Passage of the Centre.** The noise heard just at the passage of the centre is still more remarkable. All accounts, and we have many of them, agree in describing it as resembling the deafening roar of the most terrific thunder, though no thunder or lightning can be distinguished at the time, and it is a part of the storm itself, for it is at first not heard in the calm interval, but in general gradually increases as the shift comes up to the becalmed vessel. The following extracts from various sources describe it.

213. In the log of the *Exmouth's* hurricane (Cyclone), Track *s* on our Chart No. II. Mr. **Thom** gives, p. 95, the following passage, after describing a calm which lasted from 11-30, A. M. to 12-30, P. M. "with a most awful silence," during which the quicksilver disappeared in the tube of the barometer, says,

"12 P. M 20. The sun made its appearance for a few minutes, and then disappeared *followed by an awfully hollow and distant rumbling noise.* In a few minutes we received a most terrific gust from the S.S.E. laying the ship completely on her beam-ends, &c., &c."

214. Captain **Biden**, in his remarks on the log of the H. C. S. *Princess Charlotte of Wales*, says when close to, or say *at* the centre of her hurricane (Cyclone) (track *e.* on Chart No. II.)—

"At noon the barometer had fallen suddenly from 29.25 to 29.09. Sta-
"tioned every one for pumping and baling, prepared axes and secured guns,
"ports, &c. in the best possible manner. The gusts from noon until 7 P. M.
"*were like to successive and violent discharges of Artillery or the roaring of wild*
"*beasts.*"

215. In Mr. **Redfield's** Memoir on the Cuba hurricane of 1844, Amer. Journal of Science p. 359, is the following passage perfectly confirming the foregoing,—

"Captain **Cattermole,** (barque *Charleston*), states that in the night of the 6th, his barometer had fallen to 28.10, (an incorrect instrument no doubt), *attended by a continued roar in the air:* soon after the hurricane struck the ship with tremendous force from a point East to South; afterwards veering gradually to S.W., West and W.N.W."

216. I have alluded to the *screaming* of the wind in a Tyfoon. Col. **Reid** gives p. 92, a narrative by Mr. **MacQueen,** master of the ship *Rawlins,* in which he says, "The wind representing numberless voices elevated to the highest tone of screaming."

217. The violent flaws and gusts of wind at the centre noted in many logs, are also worthy of close attention. Mr. **Redfield,** speaking of these, says in his Second Memoir, p. 7.

"It is also possible that the vortex or rotative axis of a violent gale or hurricane, oscillates in its course with considerable rapidity, in a moving circuit of moderate extent, near the centre of the hurricane, and such an eccentric movement of the vortex may, for ought we know, be essential to the continued activity or force of the hurricane. Such a movement will fully account for the violent flaws or gusts of wind, and the intervening lulls or remissions, which are so often experienced towards the heart of a storm or hurricane, when in open sea; but of its existence we have no positive evidence."

Mr. **Redfield,** is inclined to suppose that independent of the two principal motions of a circular storm (Cyclone), its whirling round and moving forward, there may be a third at the centre, which he calls the Axial Oscillation, or in other words, a pendulum-like movement of the central part of a storm, such, that it does not move forward on a straight line at any time, but that while the body of the storm is whirling round and moving forward, the centre also, either moves from side to side, so that it goes forward on a waving line,

or it has a small whirling motion of its own, which if traced would form a series of corkscrew spirals at a greater or less distance from each other: or in language which sailors will understand, that the central part is constantly "taking a small round turn in itself" as it moves along. Mr. **Redfield** has, he thinks, shown some of these deviations of the course of the axis (or lull at the centre) without being able to determine them precisely; and I incline to agree with him as to the probability of their existence. This is another of the many points on which we require observations, and especially observations at sea, for to those on shore I attach very little value for such matters. (See p. 22.)

Mr. **Redfield,** I may mention, supposes, as, at least one probable cause of these oscillations of the axis, the different and varying pressures of the atmosphere within and without the Storm circle, but until we have ships sent out to experiment on Storms,* it is probable that many of these questions will remain doubtful. They are fortunately however not questions which affect the safety of the seaman, or alter his management, which is always directed to keep clear of the centres altogether; but they may throw some light on the steps by which a storm (Cyclone) is developed, and its manner of continuing to support itself as it were from its own fury, for a time, and perhaps upon the causes of the phœnomenon. In all these lights, then, the sailor who desires to aid us, should consider that neither he nor the writers on the science can yet pronounce what is, and what is not, important, and he should continue to register carefully *all* that he can collect.

218. There is an appearance of the clouds sometimes seen in hurricanes at the passage of the centre, which I trust in future will be noted and registered when it occurs. It is the following, described

* In some readers this will excite a smile. My opinion is that, if we remain at peace, it will be done within the next five years. The subject is not, certainly, of less importance than the surveys of dangerous channels or coasts, or magnetism, or hydrographical positions, or a N.W. passage; and for the honour of our flag we will not suppose that a great naval nation like England, will allow any other to precede her in systematic researches on this great national and scientific question.

in my own register of the Calcutta storm of June 1842, at the time the centre passed over that city. Track VII. on Chart No. III.

"At 3 P. M., 3rd June, calm, scud from East, but very slow and indistinct; a light air from East with drizzling rain.

"At this time I drove out on the Esplanade. The appearance of the sky was very remarkable. In the zenith the haze was so thick that the direction of the scud could not be determined, but to the East and N.E. it was slowly moving as before to the West and S. W., while in the South from thick heavy masses of clouds, the scud was rising and flying to the North and N.E."

In 1845, on the 7th and 8th March, a severe hurricane (Cyclone) was experienced at the Mauritius, and in the *Cerneen* of the 11th March, some barometrical observations and other remarks were published in that paper, which concluded with the following,

"Finally the whirlwind was distinctly shewn, when by the progress of the meteor we were involved in the actual centre of the movement of this system of circular currents. In fact we then observed all around us winds in all directions, without feeling the effect of any. The clouds at sea were moving to the North and those of the mountains to the South, *while at the Zenith every thing was perfectly stationary.* I should observe, that the directions of the wind have not been exactly taken."

These are both instances in which the opposite movements have been distinctly seen, and they are always of much importance as shewing how clearly the circular motion has been proved, if indeed that can be any longer questioned, by the followers of Mr. **Espy** and professor **Hare** in America; for I do not recollect that any European authority in science has doubted of its existence.

219. **The sizes of the central calm space** of hurricane storms (Cyclones,) or more properly, taking them as circles, their diameters, appear to vary very much. The sailor however must be careful not to confound this, the actual measurement of the lull, with the time it may perchance take in passing over his ship; for it is clear that three storms (Cyclones) having respectively central spaces of 5, 10, and 15 miles, would each take half an hour to pass over an anchorage if their rates of motion were 10, 20 and 30 miles per hour; and at sea it is difficult, on account of the drift or run, and the very few notes usually taken, in times of such anxiety and

danger from the rolling and shift of wind, to calculate with any precision what the diameter of the lull is. Of the few shore observations we possess, the following are notes.

Mr. **Thom** calculating from the time the calm began at one point and reached another at the Mauritius, p. 171, estimates it to have been about 21 miles for a storm moving at the rate of 5 miles per hour.

My own estimate for the Calcutta hurricane (Cyclone) of 1842, is, that in a vortex moving at the rate of 5.3 miles per hour, the breadth of the lull at the centre was 11 miles.

220. It is possible, and in this view, as will be presently seen, Mr. **Thom** partly coincides with me, that at least at the commencement of hurricanes (Cyclones), if not after their full formation, the calm space or lull at the centre is so wide in proportion to the whole extent of the storm, that fully one-third of its breadth is occupied by the calm! I think upon good grounds that I have traced something of this kind in one very clear instance, of which the details, which I extract and abridge from my Fourteenth Memoir,* are briefly as follows:

The ship *Caledonia*, Captain **Burn**, of 1000 tons, from China to Bombay, overtook the storm (Cyclone) marked XIV., on Chart No. III., and *sailed into it* from its Eastern side, and this apparently, as shewn by the log of another vessel, on the first day of its formation; sailing along with it and reaching the centre where she was obliged to lie to. The track and rate of travelling of the storm, as also the position and run of the ship, are well ascertained, so that we can say with tolerable certainty that she found the central space to be about thirty miles in diameter, and the zone of hurricane around it not more than thirty-five miles in breadth! and either on account of this wide space,† or because the hurricane was not fully formed, (though

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* Journal Asiatic Society, Vol. XIV.

† Proportionally speaking. Thirty miles would have probably been a moderate central space for a storm of 500 miles in diameter, and a small one, for one of 800 or a 1000.

it *was* violent enough to oblige them to cut away the sails they had set after the shift), they found at this wide centre only a heavy "swell," and not the *sea* which is usually felt there, and which was felt by other ships as the storm (Cyclone) progressed.

221. Mr. **Thom's** view is (p. 201) speaking of the great hurricanes of the Southern Indian Ocean, that "in the early stages it is probable the calm is very extensive, and embraces several vortices which gradually merge into one."

Analogous to storms (Cyclones), and, for any thing we yet know, produced by the same causes are the sand storms and dust-whirlwinds of deserts and hot countries. Of these we shall speak a little more in detail in Part V., but I allude to them now to mention a curious account given to me of an Indian dust-whirlwind by Mr. **Rochendorf**, a highly intelligent German traveller, educated as a mining engineer, who had run after and penetrated several of them in Upper India, where they are very common, and sometimes of considerable size. He describes them as forming a thick broad wall of dust, through which it was half suffocation to penetrate, but when in the centre it was nearly calm, with nothing but the wall of dust visible. He further told me, that he had seen large ones commence, and that they did so in segments, which afterwards united.

222. **Electricity and Electro-Magnetism.** ELECTRICITY. We can merely speculate on the part which electricity may play in hurricane storms (Cyclones), and in so doing be careful that we do not mistake mere effects which are visible, for *causes* which are hidden.

It is remarkable that at times in some of these storms (Cyclones) electricity, in its common forms of thunder and lightning, seems to be most abundantly developed, while in others, and this by far the greater number of those at sea, it seems not to have gone beyond common lightning, which sailors often omit to notice unless it is very severe. Mr. **Thom** makes this remark, and further says, that at the Mauritius (where he resided for some time) thunder and lightning are so rare during their hurricanes, that some affirm that it is never present! With respect to thunder, however, we may remark once for all that, only the very loudest would have any chance of being heard during the height of a hurricane (Cyclone).

In the hurricane (Cyclone) of June 1842, of which the centre passed over Calcutta,* and which was of excessive violence, there was certainly no lightning, nor any thunder heard, even at night, and mention is rarely made of it in the accounts of the hurricanes (Cyclones) of the Bay of Bengal or China seas. On the other hand, in the Barbadoes hurricane of 1831, as quoted by Colonel **Reid**, p. 30, we find that the development of electricity was awful as to its extent and appearance, but there seems to have been no special mischief occasioned by it; the whole atmosphere of the place appears to have been enveloped in an electric cloud while constant discharges were going on. A remarkable light and a "darkness" is also mentioned in some accounts† of these tempests,‡ and in the whirlwind of the *Paquetbot des Mers du Sud*, detailed in my Fourth Memoir, and already alluded to p. 30, it appears that the onset of her tornado-hurricane was accompanied with some electric explosion.

223. In many instances the passage of the centre, or the shift of wind which indicates it when there is no intervening calm, appears to be marked by electric discharges, and what is very remarkable, by a *single heavy flash* or two of lightning! This also sometimes occurs towards the close of the storm, and when the wind is a little abated, as if there was a peculiar zone of the storm (Cyclone) in which the electric action was going on?

In a letter from Captain **Compton**, of the *Northumberland*, to his agents in Calcutta, he describes this kind of lightning; and as he does not allude to lightning before, but only to a "lurid strange appearance," which may have been an electric light, I presume there was none of any remarkable intensity. He says —

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* Seventh Memoir, Journal Asiatic Society, Vol. XI.

† *Judith and Esther.* **Reid**, p. 76. *A great light* was observed during the hurricane (Cyclone) of December 1845, at Baticolo, on the East Coast of Ceylon, **Pid.** XIV. Memoir, Jour. As. Soc. Vol. XIV.

‡ Dr. **Peysonnel** (*Phil. Trans.* for 1756, p. 628), says that the lightning appears and the thunder is heard *at the close* of the West India hurricanes.

"Between 3 and 4 A. M., two immense flashes of lightning took place. In half an hour afterwards the wind abated, and the frightful lurid appearance ceased."

Another account printed in the Calcutta newspapers, says that—

"At 2 A. M., a flash of lightning shewed them the loss of the foremast (which no one heard going over the side in the uproar of the elements), and then, that "at 4 o'clock, *after another flash of lightning*, the wind suddenly stopt."

It would then appear that only two notable flashes were seen.

In the log of the *Eliza*, Capt. **McCarthy**, which ship was dismasted, and near foundering in the Pooree and Cuttack hurricane (Cyclone) of October 1842, which is the subject of my Ninth Memoir, (Journal Asiatic Society, Vol. XII.), no lightning is adverted to 'till the calm centre reached the vessel, where "much lightning" is noted, and immediately afterwards it is stated that —

"The wind shifted in a flash of lightning suddenly to the S.S.E. from N.N.E., and blew instantly nearly as violently as before."

The ship *Thomas Grenville*, Captain **Thornhill**, experienced a severe hurricane (Cyclone) in Lat. 25° South, Long. 26° East, (Track on Chart No. II.) No lightning seems to have occurred till just at the approach of the centre, when it is said —

"At 2 P. M. Bar. 28.90 (from 29.80) one very vivid flash of lightning, and a loud clap of thunder now occurred. At 1-15 P. M., it moderated to a strong breeze for ten minutes, when the hurricane came on with (if possible) redoubled violence; at 4 P. M. Bar. 28.70."

224. There is no doubt that during hurricanes (Cyclones) immense electric action must be going on in the atmosphere, for we know that every change of state of all bodies in nature, as water into vapour, or gas (steam), or the moisture of the air again condensed into water and falling as rain, gives rise to it. Hence while prodigious torrents of rain are falling for days together over hundreds of square miles in these great storms (Cyclones,) a vast amount of electricity must be generated, but it is possible that at

the same time it is carried off, i. e. conducted to the earth or sea, by the rain itself, as fast as it is formed. The fires of St. Elmo, as they are called, which remain for hours together at yard-arms and mast-heads of ships in blowing weather, are instances of permanent electric action existing between the atmosphere and the sea, through the ship as a conductor.

225. Mr. **Thom** thinks, and gives data to show, that lightning is much oftener developed on the equatorial sides of hurricanes (Cyclones) than on the opposite ones, but he is on the whole inclined to think it an *effect* rather than a *cause* of rotatory storms.

The following is given by Mr. **Thom** from the log of the *Fairlie* when at the centre of her hurricane (Cyclone), in Lat. 12° 2′ South, Long. 103° 41′ East.

"The wind now at S.S.W. and awful lightning flying about in all directions; large balls of fire or meteors were seen at every yard-arm, mast-head, or boom-end: Appearance most awful. * * * * * From the flashes of lightning (no thunder) *a heavy cloud seemed to be down upon us.*"

This ship had, literally, every thing but the bare lower masts *blown* out of her, and narrowly escaped foundering.

226. The fact is that we have very few and very imperfect data on which to found any opinion, and for any practical purposes, our present knowledge is quite useless. Nevertheless careful seamen and all who are desirous of advancing human knowledge, will, I trust, neglect no opportunity of noting all that may fall under their observation, how trifling or indifferent soever the appearance may be supposed as to its relations to the causes of the storm. In Part V., when speaking of water-spouts, we shall perhaps be obliged to go into some details of electric action in them which may suggest many points of enquiry; and in the section treating of the signs of approaching hurricanes (Cyclones), it will be seen that one kind of lightning, at least, is a remarkable precursor of them in some instances.

227. Although the following from **Kaemtz'** Meteorology, p. 366 relates rather to what are called *storms* (thunder storms) on shore, than to our hurricane storms (Cyclones), yet it is worth insertion, as

showing how much we have yet to learn even in these constantly recurring and most familiar of meteorological phænomena.

"ELECTRICITY OF STORMS. Notwithstanding the numerous researches that have been undertaken on this subject, it is still enveloped in great obscurity. Place yourself near an electrometer, and observe it during the whole course of a storm, and you will see how variable its indications are. The lightnings are actually very near without the most delicate instruments giving the least sign of electricity; suddenly the latter increases at the moment of a very powerful flash. Another day the storm arrives with all the signs of a very powerful electric tension, lightning plays in the clouds, the two straws of the electroscrope collapse, and it is some time before they open again, At one time, the electric tension will vary for every class of thunder, at another time it will remain the same for a quarter of an hour, although the lightnings rapidly succeeded each other. In one storm the straws separate rapidly; a flash of lightning occurs, and they collapse; during another, they fall together, and then diverge rapidly to approach slowly, until a fresh clap of thunder makes them diverge again. The electricity may be for a long time positive, its force alone varies; but soon, while the rain, the clouds, the wind, and the lightnings, remain the same, the straws separate sometimes under the influence of positive, at other times under the influence of fluid of the contrary sign.

"If we compare all that has been written upon storms, we do not hesitate to conclude that they are the most complicated phænomena of meteorology. I suspect that a long time will elapse before we can account for all the circumstances by which they are accompanied. First, a single observer is insufficient to collect all the data; we ought to note the electricity, the direction of the wind, the movements and the form of the clouds, the size of the drops of rain, and the direction in which they fall, the form and place of the lightnings, and the divergence of the straws of the electrometer; each of these phænomena requires all the attention of an observer, who also looses valuable time in writing his remarks. Several additional observers are necessary, who being dispersed over the whole surface where the storm is visible, should each notice all the indications in his station, and compare them with the rest.

"All the capricious indications of the electroscope are due to its being influenced by several strata of superposed clouds, which act and re-act on each other and on the earth, so that the electricities are developed and neutralized alternately. We are accustomed in storms to see the most powerful developements of electric tension, and it is difficult to conceive how lightnings and claps of thunder could occur without there being a very notable electric tension."

And again speaking always of thunder storms, he says, p. 364,—

"In all cases a rapid condensation of vapours is the essential condition for the formation of storms: if electricity is very powerfully developed, there is a

storm, if not there are simply passing showers, accompanied by very marked signs of electricity. If we examine all the circumstances that accompany the developement of electricity, we must consider the condensation of vapours as the cause of its production, and conclude that it is the storm that produces the electricity, and not the electric tension that produces the storm, as is the general opinion. Violent rains without thunder and lightning are distinguished from storms merely by a lesser developement of electricity, whence proceeds the absence of lightning and thunder."

228. ELECTRO-MAGNETISM has been adverted to by Colonel **Reid** as perhaps having some connection with the rotatory character of storms, and their opposite motions in the different hemispheres, and the lines of magnetic intensity with the occurrence of storms, but every thing on this part of the subject is so speculative, that we can do no more than simply allude to it. I may add, that Mr. **Thom** adduces some arguments and data in opposition to this theory.

229. **Arched Squalls and Tornados, &c.** It has been presumed, and with some show of probability, that some Tornados, meaning by this word one kind of those which occur on the Coast of Africa, have a relation to circular storms (Cyclones); that is to say, they are in fact sometimes *supposed* to be truly miniature ones, as to their motions, extent, and duration. Their violence we well know to be excessive. I shall first make some remarks on the Arched squalls.

230. The most remarkable of the Arched squalls, perhaps in the world, as to the regularity of their formation, frequent occurrence, similarity of appearance, and excessive violence, are those of the Straits of Malacca. The North-westers of Bengal, during the hot season, and one class of the Tornados of the coast of Africa may come next, and then the *Pamperos* of the Rio de la Plata, which seem, at least sometimes, to be of this kind. Those of the Straits of Malacca most usually occur at night or late in the afternoon, and very rarely if ever in the morning or before 4 P. M., which is another peculiarity. They are most common when completely within the Strait, or between the latitude of 5° North, and the Straits of Singapore, and are most frequent about the middle or opposite to Malacca, where the Strait is completely

shut in by the island of Sumatra.* They may be said (that is the heaviest of the wind invariably) to come from some point between N.N.W., and W.N.W., North West being the most usual.

"They rise," says Horsburgh, "with a black cloudy arch, rising rapidly from the horizon to the zenith, and scarcely allowing time to reduce sail." Perhaps they are better described by saying that a mass of black clouds collects and rapidly rises, forming a vast and magnificent arch, beneath which is always observed, even in the darkest night, a dull, gloomy, phosphoric light, like that transmitted through oiled paper by a candle, which at times becomes stronger, particularly on the approach of the arch to the zenith. Flashes of very pale sheet lightning are often observed crossing this space, which sometimes extends over 10 or 12 points of the horizon; the low grumbling of thunder, the falling of the rain, and even the distant roar of the wind, may, I think, be distinctly heard as the arch rises. They are sometimes, but not always, accompanied by heavy thunder and lightning in which many ships have been struck, but the danger is from the wind, the first burst of which is always tremendous, and sufficient to dismast or upset the finest frigate, should she venture to meet it under any but storm sail, and many vessels have been lost by sleepy or rash officers allowing themselves to be caught in them. Towards the end of the squall the wind veers a little, but there is nothing, that I have ever heard of, to induce the supposition that the blast is other than one blowing in a direct line, but I advert to these squalls and to kinds subsequently mentioned in reference to Mr. **Hopkins'** theory of their being descending winds or gusts; or as he expresses it, parts of a "vertical wheel" (vortex.)

231. The Northwesters of Bengal are at times excessively violent, and sometimes equal those of the Straits of Malacca in their regularity of arching. I have known them preceded a few minutes before their onset by a whirlwind, which had some appearance of a water-spout in the elongation of the cloud and the effects produced on the water

* The heavy squalls, or short gales, of sometimes 6 or 8 hours duration, which came from the S. Westward are called Sumatras, they more usually arise like common squalls, and have not the constant tendency to arch, which so strikingly distinguishes the others.

of the Hooghly and on large boats upon it. On land it was strong enough to unroof a stout-built bungalow.*

232. The following from Mr. **Hopkins'** work, p. 71, is the extract given by him from the voyage of H. M. S. *Beagle*, describing a "*Pampero*" in the Rio de la Plata.

"On the 30th January, 1829, the *Beagle* was standing in from sea towards the harbour of Maldonado. Before mid-day the breeze was fresh from the N.N.W., but after noon it became moderate, and there was a gloominess and a close sultry feeling, which seemed to presage thunder and rain. During three preceding nights banks of clouds had been noticed near the S.W. horizon, over which there was a frequent reflection of very distant lightning. The barometer had been falling since the 25th slowly but steadily, and on the 30th at noon it was at 29·4 inches and the thermometer at 78°. At about 3 o'clock the wind was light, and veering about from the N.W. to N.E. There was a heavy bank of clouds in the S.W., and occasional lightning was visible even in day-light. There were gusts of heated wind. At 4 the breeze freshened up from N.N.W. and obliged us to take in all light sails. Soon after 5 it became so dark towards the S.W., and the lightning increased so much, that we shortened sail to the reefed top-sails and fore-sail, shortly before 6 the upper clouds in the S.W. quarter assumed a singularly hard and rolled or tufted appearance, like great bales of black cotton, and altered their forms so rapidly that I ordered sail to be shortened, and the top-sails to be furled, leaving set only a small new fore-sail. Gusts of hot wind came off the nearest land at intervals of about a minute. The wind changed quickly, and blew so heavily from the S.W., that the fore-sail split to ribbons, and the ship was thrown almost on her beam ends! The main top-sail was instantly blown out of the men's hands, and the vessel was apparently capsizing, when top-masts and jib-boom went close to the caps, and she righted considerably. Two men were lost. The starboard boat was stove by the force of the wind, and the other was washed away, and so loud was the sound of the tempest that I did not hear the masts break though holding by the mizen rigging. Never before nor since have I witnessed such strength, or I may say weight of wind; thunder, lightning, hail, and rain came with it, but they were hardly noticed in the presence of such a formidable accompaniment! After 7 the clouds had almost all passed away; the wind settled into a steady S.W. gale, with a clear sky."

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* The Indian term for a thatched, but European fashioned house.

In **Purdy's** Atlantic Memoir, Part II., p. 186, Captain **Peter Heywood,** R. N., who has given excellent sailing directions for the Rio de la Plata, the results of three years' experience on that station, speaks of the *Pamperos* as S.W. gales only, and does not allude to their veering at all.

233. In **Webster's** voyage of the *Chanticleer*, the *Pamperos* of Buenos Ayres are thus described—

"The following indications of a Pampero have frequently fallen under my observation. The weather is getting sultry during a few days with a light breeze from the East or N.E. ending in a calm. A cool light wind then sets in from South or S.E., but confined entirely to the lower strata of the atmosphere, *while the clouds above it are moving in the opposite direction from N.W. to S.E.* The Northern horizon, as night advances, becomes dark, with heavy lowering clouds, accompanied with lightning from the East or N.E. The Southern wind now ceases, and is followed by variable winds from the Northward. Heavy clouds are thus brought over; and lightning accompanied by thunder, follows in a most terrific manner. The wind veers gradually to the Westward in violent gusts, the lightning becomes more vivid and thunder more awful, a gale of wind follows from the S.W. more violent, but of short duration, and fine weather begins."

We may thus dismiss this class of the minor hurricanes* as certainly belonging to that of the right-lined and not circular winds.

234. Tornados of the West Coast of Africa. Colonel **Reid,** p. 512, says that from explanations received from naval officers, as well as from some log-books, he should be convinced that the tornados on the West coast of Africa, as well as the *Pamperos* on the coast of South America, and also arched squalls, are phœnomena altogether different from the whirlwind; but the evidence has not proved reconcileable, and he gives sundry logs of H. M. S. *Tartar*, from April 3rd to June 2nd, in which various *tornados* are noticed, one of which veered round the compass, while the others seem to have blown from the N.E. S.E. and Eastward, but he does

* Using this word to express their violence only.

not seem aware that seamen, and especially such as keep but brief logs like the one quoted, often mean to express by the words "came on a heavy tornado from the S.E." only that it *began* at that quarter, and not that it also ended there. Nevertheless, there is no doubt that many of these African tornados are merely squalls.

And it is to this point that I would direct the attention of the intelligent seaman, namely that there may be ready two distinct classes of these little tempests. The first merely gusts of wind and rain in one direction, or straight-lined winds, and the second true circular storms (Cyclones) in miniature.

235. In **Purdy's** Atlantic Memoir, Part I., pages 69, 70, the following description is given of these phœnomena from **M. Goldsberry,**

"Between Cape Verga and Cape Palmas, and during the months of May, June, July, August, Sept., and October, the countries near the sea are frequently exposed to hurricanes, which the Portuguese have denominated tornados, and which have obtained this name even amongst the negroes. During my stay in the river of Sierra Leone, I witnessed one of these tornados, but it was not one of the most violent. These meteors happen a few weeks before the rainy season, and continue till the month of November. The countries above described are, therefore, exposed to them for nearly six months, and these whirlwinds are more or less frequent, and of different degrees of violence, according to the state of the atmosphere.

"This part of Africa generally experiences ten or twelve of these hurricanes in a year, and it is easier to describe their effects than to discover their cause. They are characterized by circumstances which deserve all the attention of philosophers.

"The sky is clear, a perfect calm has prevailed for several hours, and the weight of the air is oppressive. Suddenly, in the most elevated region of the atmosphere, is perceived a little round and white cloud, the diameter of which does not appear to exceed 5 or 6 feet: this cloud, which seems to be fixed and perfectly motionless, is the indication of a tornado.

"By degrees, and at first very gradually, the air becomes agitated, and acquires a circular motion. The leaves and plants, with which the land is always covered, rise several feet from the soil; they keep incessantly moving and revolving around the same spot.

"The negroes, who pass their lives like children, amuse themselves with this rotatory motion; they follow the turn of the agitated leaves and plants, laugh at their innocent amusement, and announce the approach of the tornado.

"The cloud, which is the indicator of this pheenomenon, has now increased in size: it continues to spread, and insensibly descends to the lower region of the atmosphere; at length, it grows thick and obscure, and covers a great part of the visible horizon.

"By this time the whirlwind has increased, the vessels in the Bays double their cables, or drop anchor near the shore; the tornado becomes violent and terrible; the cables often break, and the violent agitation of the ships causes them to run foul of each other.

"Many negro huts are swept away, trees blown up by the roots, and, when these whirlwinds exert their full violence, they leave deplorable traces of their progress. These meteors happily last only a quarter of an hour, and terminate by a heavy rain.

"The maritime countries to the northward, comprised between Cape Blanco and Cape Verga, are not subject to these phœnomena; it is only to the South of the latter Cape, and as far as that of Palmas, that they are felt in their full violence; and they always occur at the same periods. Some topographical circumstances, peculiar to this part of Western Africa, are, doubtless, among the number of causes of these whirlwinds."

236. The following is abridged from Mr. **Hopkins'** work, p. 74, describing, from **Laird** and **Oldfield**, an African tornado:—

"At the approach of a tornado, a dark mass of clouds collects on the Eastern horizon, accompanied by frequent, loud, but short noises, reminding one of the muttering and growling of some wild animal in a voice of thunder. This mass or bank of clouds gradually covers one half of the horizon, extending to it from the zenith; but generally before this a small and beautifully formed radiant arch, on the verge of the horizon, appears and gradually increases. Long before it reaches the vessel the roaring whistle of the whirlwind is heard, producing nearly as much noise as the peals of thunder that seem to rend the very clouds apart from each other. The course of the squall is distinctly marked by the line of foam it throws up, and I have stood on the taffrail of a vessel, and felt the first rush of the wind while her head sails were becalmed. The sensation of relief from the oppressive heat which the tornado produces afterwards is most cheering and delightful."

In the following part, in the section in which I speak of the formation and breaking up of hurricanes (Cyclones), I shall perhaps advert again to some of the peculiar appearances and effects just described.

237. **Earthquakes.** There appears no reason to doubt that at the approach of, and during *some* hurricanes, shocks of earthquakes

have been felt; but it is impossible to say, as yet, if these have any relation as cause and effect, though earthquakes are supposed now to have more connection with the state of the atmosphere than was formerly allowed. No one indeed can have resided in tropical countries subject to these commotions, without having remarked, that some connection certainly exists, by the peculiar state of the weather preceding the shocks.

238. We should bear in mind that at sea, unless the shock was one of a most peculiar kind and extraordinary force, it certainly would not be felt, and on shore also, unless during the calm, it would require to be much stronger than common shocks usually are, to be distinctly felt in the shaking and uproar of a storm. Hence we must allow that slight shocks may occur during hurricanes much oftener than is supposed. Nevertheless Colonel **Reid's** remark that "it is very material to the success of the present investigation, that the phœnomena of hurricanes and earthquakes should not be connected without proof," should not be forgotten. The earliest notice I can find of a storm and earthquake occurring together, is the following in the Gentleman's Magazine for 1738-39, which I copy from Dr. **Martin's** Medical Topography of Calcutta, the italics are mine. It is stated that—

"On the night between the 11th and 12th October 1737, there happened a furious hurricane at the mouth of the Ganges, which reached sixty leagues up the river. *There was at the same time a violent earthquake* which threw down a great many houses along the river-side in Golgoto (i. e. Calcutta), alone, a port belonging to the English. Two hundred houses were thrown down, and the high and magnificent steeple of the English church sunk into the ground without breaking. It is computed that 20,000 ships, barks, sloops, boats, canoes, &c. have been cast away: of nine English ships then in the Ganges, eight were lost, and most of the crews drowned. Barks of sixty tons were blown two leagues up into land over the tops of high trees; of four Dutch ships in the river, three were lost with their men and cargoes; 300,000 souls are said to have perished. The water rose forty feet higher than usual in the Ganges."—*Gentleman's Magazine for* 1738-39.

It would seem, judging by what we know of the storms of the Bay of Bengal, that in all probability this must have been a true

hurricane (Cyclone), and if so it is a very exact case of the hurricane and earthquake occurring together.

239. The next is more modern, being the Ongole storm of October, 1800, Track *a.* on our Chart, No. III. In the Asiatic Annual Register, Vol. III. for 1801, it is stated in a report from Ongole, that—

"On the 19th instant (October) about 10 minutes after 4 A. M., the wind blew a hurricane, *when suddenly we felt a severe shock of an earthquake, which kept the earth in continual agitation for nearly a minute.* It shook down many houses, but I believe no person was killed in consequence."

The writer, evidently himself a partaker in the calamity, goes on to describe the sad distress occasioned by the storm, which was evidently one of tremendous intensity.

240. In the log of the American ship *Unicorn* of Salem, forwarded to me by Mr. **Redfield,** under date of October 30th, 1843, the ship then lying at Manila, (it is not said if at the Bar or at Cavite), it is stated—

"7 P. M. thick and rainy, and has been so for 24 hours; *felt two heavy shocks of an earthquake;* blowing fresh. The barometer (which was at 29.90 A. M.) was now 29 84, and at 10 P. M. a severe hurricane (Cyclone) commenced." This is an instance of the earthquake preceding the onset of the storm.

241. It is a curious question, if we assume the hurricanes and earthquakes to be connected, since the storms last for hours, and the earthquakes but for minutes, to investigate the precise points both of place and time of the storm, at which, if for the present we may use the term, the earthquake "explodes"? Colonel **Reid** from careful enquiry on the spot, is inclined to believe that there was not any shock during the Barbadoes hurricane. What is above stated, however, will I trust direct attention to the subject, and we shall no doubt, obtain gradually a much more extended and correct view of our subject.

PART V.

BAROMETER AND SIMPIESOMETER, CAUSES OF THEIR MOTIONS. 2, RISE OF BAROMETER BEFORE STORMS. 3, OSCILLATIONS OF THE BAROMETER. 4, BAROMETER AS A MEASURER OF THE DISTANCE OF THE CENTRE. 5, HEIGHT OF STORMS ABOVE THE SURFACE OF THE OCEAN. 6, BANKS OF CLOUDS. 7, SIGNS OF APPROACHING HURRICANES. 8. SEASONS AT WHICH HURRICANES OCCUR. 9, WHIRLWINDS AND WATER-SPOUTS. 10, FORMATION AND BREAKING UP OF HURRICANES. 11, POINTS OF ENQUIRY AND DIRECTIONS FOR OBSERVERS. 12, MISCELLANEA AND CONCLUSION.

Throughout the preceding parts the word Cyclone has been, as proposed at p. 9, added after the words in common use to express circular-blowing winds. In this part I propose to use it alone, employing the common words "Storm," "Hurricane," &c. to express the *strength* of the wind. H. P.

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242. **Barometer and Simpiesometer.** I am aware that if I begin by telling the seaman that he *should* have a good barometer and simpiesometer on board, I may to some, who though fully aware of their value and uses cannot afford these instruments, be like the physicians who order change of air, nourishing food, and wine to poor patients who have not the means of paying for them. I will then address this to owners, underwriters, freighters, and above all to GOVERNMENTS, Home and Colonial, which have so often such large amounts of stores, and so many hundreds if not thou-

sands of valuable lives,* costing it thousands of pounds in mere outlay, afloat. Owners and underwriters do not want to be told that the policy is vitiated, if the ship be not properly found in the usual sea stores, ground-tackle and the like, and yet how few of them dream of the enormous amount of mischief, for which some one, eventually, must pay, arising from the want of books, charts, and instruments! I trust that those who may read this work will find in it so many additional motives for ships being provided with a barometer and simpiesometer, they would no more think a ship, or themselves, fairly dealt with if sent to sea without them, than if sent without pumps. Pumps indeed are but precautions against leaks *after* they occur; barometers, simpiesometers, and the Law of Storms duly studied, are precautions against that which for the most part gives rise to the leaks, and which may prevent their occurrence; and whether the owner wishes his ship to escape the racking and straining, and losses of spars, sails, &c. of a hurricane, the underwriter to escape the payments which so much reduce his profits, or the Captain to acquire the credit of a fortunate if not of a clever master, they will all find that *the commander who is watching his barometer is watching his ship*, and that in the most efficient manner.

243. **Cause of the motions of the Barometer and Simpiesometer.** The atmosphere of the globe in which we live may be best likened for sailors to a thin coating of air all round the earth. It is thin in comparison with the globe of the earth though supposed to extend to 40 or 50 miles in height, (thickness); but then this is

* In a memorandum submitted to the Government of Bengal in October 1846, I showed that within a few months, 50 ships and 10,000 men, coolies and troops, would be afloat from India; and that most of these would have to cross two if not three hurricane tracts on this side of the Cape of which no one in England, judging by the instructions sent out, appeared to have had any sort of knowledge! In our wars thousands of men, and hundreds of thousands of pounds worth of stores, are constantly afloat. While the Memorandum was before Government, the ship *Sophia Frazer*, from Amoy with Chinese emigrants ran headlong into a furious tyfoon, and at its close it was found that nearly thirty of the unfortunate Chinese had been suffocated for want of air! all hatches being necessarily closed.

round a ball of 8,000 miles in diameter, so that (using always round numbers,) it is only $\frac{1}{200}$th part of the diameter or $\frac{1}{100}$th part of the semi-diameter of the earth. If we dipped a small globe of eight inches in diameter into a varnish or solution of gum Arabic, till a coat of $\frac{1}{23}$ of an inch thick was formed over it, this would represent the atmosphere as to height, but then we must recollect that the air is a highly moveable and elastic fluid, and is constantly changing also its heat and the quantity of moisture it contains. Moreover, it is not, like the varnish, of the same density (consistence) throughout, but varying from the surface of the earth, where it is most dense, to the extreme limits of the atmosphere where it is much lighter than any thing we can express.

The effects of winds or other causes also are to *heap up* as it were, the air over one part of the earth like a wave, and this *seems* to form a corresponding hollow in other parts. These waves and depressions may be of course straight, or crossing each other, and circular, or of any other form just as in other fluids.

244. It is evident that if there is more air in one part and less in another, or if the air in one part is lighter or more dense (as from containing more vapour or being heaped up) than in another, a column of it extending from the earth's surface to the limits of the atmosphere in that part, will be heavier or lighter than in other parts; or than it usually is in that spot. Now the barometer* and simpiesometer *measure the weight* of the atmosphere, or the weight of the column of air *over the spot at which they are placed, but only there.*

How they are demonstrated to do this will be found in any treatise of Natural Philosophy. The *average* weight, or *pressure* as it is usually called, of the atmosphere, at the level of the sea, is a little more or less equal to that degree of weight, or pressure, of it which would support a column of mercury of 30 inches in height, and

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* The name Barometer signifies "*measurer of weight.*" Simpiesometer "*a measurer together with,*" because it measures *with* the barometer. It had better have been called a Proterometer "*a measurer before,*" for it always shews the changes before the barometer.

in the common wheel barometer and simpiesometer it may be seen that the tube instead of being inserted into a cistern of mercury, is curved up only for a few inches at the end, and that these few inches of mercury or oil, *with* the pressure or weight of the atmosphere, support (or weigh as much as) the 30 inches of mercury, or the column of it in the long tube on the other side, so that if the air is heavy, or there is more of it, the barometer rises, and when lighter it falls.*

As I have before observed, heat makes the air lighter, but enables it to absorb more vapour or steam, and this vapour itself affects the weight of the atmosphere; but at present, and for common practical purposes to which I now come, the seaman has little or nothing to do with this. For him, and for our science of storms, the considerations are simply, the rates and causes of the fluctuations as far as we can discover them, and what amount of danger or safety they indicate to us, and how they do so.

245. To Mr. **Redfield** is due the honour of the theory which appears to explain completely the extraordinary fall of the barometer in circular storms (Cyclones), and moreover the rise which often precedes their onset; and I do but use his mode of illustration in the following explanation of it, though I add a little to it, to make it more distinct for the plain seaman, who, if he will make the little experiments which I now describe, will perfectly understand the fall of the barometer in these tempests; and moreover, will, whenever he pleases, be able to make a miniature Cyclone for his amusement or instruction, or that of others.

a. Take a common, and a plain flat-bottomed beer tumbler, such as are usually carried on board ships, and mark on a sheet of paper a circle of the size of the bottom of it.

b. Make a few marks or figures for ships, one about the centre of this circle, one or two more at different distances from it, and one outside of the circle, all in the same line.

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* The upper closed part of the tube, which in good barometers is a perfect vacuum, is left so to allow of the free rise and fall of the mercury which is thus measured. In the simpiesometer this part is filled with hydrogen gas.

c. Fill the tumbler a little more than half-full of water, and place it over the mark.

d. Stir this water round smartly with a tea-spoon or paper-knife, and then look at the tumbler *sideways;* you will see that the water forms a cone at the top, and that if we call the column (depth) of water two inches at the edges, it is only about one and half inches at the centre.

e. Now consider your paper as the ocean, the circle as a storm circle of 500 miles in diameter, if you like, and the water to be air, representing the various heights, and consequently different *weights* of the atmosphere over different parts of the storm circle, and upon the ships (and consequently on their barometers) which we have marked in it. It is clear that the ship at the centre has the *least* pressure on her barometer, which is therefore very low, and that those at different distances have more and more, (their barometers higher) while the one outside has it at about the mean height, or even a little higher if we suppose the atmospheric wave rolling off or driven up above the usual height, as will be afterward explained.

f. The seaman may very instructively vary this experiment by throwing a few grains of powdered biscuit, black lead or coal (which is better) into the tumbler, stirring it well as before, and *looking down* from above at the little ship-marks. He will see the grains passing over the ships, and showing the course of the wind-arrows in a Cyclone, and if he marks a track and moves the tumbler along it he will see how a Cyclone successively strikes, passes over, and leaves ships: lowering and raising their barometers accordingly; and how the circular currents of winds veer differently on different sides of the track! He has thus a complete miniature of the Cyclone in his hands, and he may *make one,* for either hemisphere, by stirring the water with or against the hands of a watch.

246. Before I conclude this section, I would impress on seamen the importance of obtaining *good* barometers and simpiesometers; and these cost but little more than bad ones; and the utility of comparing them with any known good ones at any ports they

may arrive, as for instance with those at public establishments, &c. It is not requisite that this should be done with all the accuracy of comparisons for altitudes with standard instruments, but it is highly useful to know what the error of a barometer is when we come to compare with other ship's barometers, and when we wish to use it in assisting our judgment in forming an estimate of our distance from the centre of a Cyclone.

The following note is from my former work on this subject.

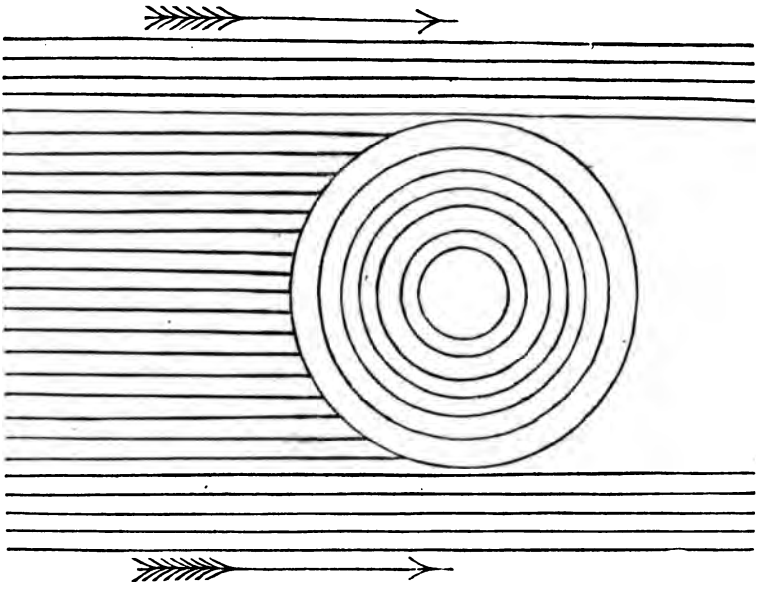
"I have little doubt that the oil in the common simpiesometers is affected by light, and becomes viscid when exposed to it. Messrs. **Troughton** and **Sims**, at my suggestion, have manufactured a "Tropical Tempest Simpiesometer," of which the two principal improvements are, a door to keep the light from the oil, except when observing, and a tube of such a length, that it will allow of the great depression (to 26 or 27 inches) which sometimes occurs, with a temperature of 75 or 80° in tropical hurricanes, without any risk of the gas escaping. See Journal Asiatic Society, Vol. XII."

Learning after this note was published, that the house of **Adie** and Co. of Edinburgh still existed, (I had been told that Mr. **Adie** who first invented the simpiesometer was no more), I wrote to them, and in their reply they inform me, that they *had* found oil to thicken, and now use an acid; as also that they had made their tubes long enough to act safely at a temperature of 120° and 27 inches, but should now make them long enough for a pressure of 26 inches. The improvement in both sorts of the instruments will be thus accomplished.

247. **Rise of the Barometer before Storms.** Colonel **Reid**, p. 518, explains this as follows: and from what we have said before, p. 179, of Atmospheric waves, it may be easily supposed that something of the kind suggested does take place.

"A progressive whirlwind of great extent, might have the effect of arresting the usual atmospheric current, and of heaping it up to a sufficient extent on one side of the storm, so as to affect the barometer, by increasing the atmospheric pressure; whilst on the opposite side of the same whirlwind, the atmospheric pressure, beyond the limit of the storm, might be found to be somewhat less than ordinary."

"The following diagram is intended to render this explanation more easy. The circle is intended to represent an extended storm in high latitudes; and the parallel lines the prevailing westerly atmospheric current."



"The same figure may also serve to explain why progressive revolving storms are often preceded by calms; and why a rise in the barometer may sometimes precede the setting in of a storm."

248. **Oscillations of the Barometer and Simpiesometer.** Another peculiarity of the barometer and simpiesometer which undoubtedly often occurs, is their "Oscillation" (rising and falling within a short space of time) before and during a Cyclone. In one case in a Tyfoon-Cyclone, in the China Sea in October 1840, in which the transport *Golconda* with 300 troops on board foundered,* the simpiesometer was observed in another ship which avoided it, to oscillate for 24 hours before the Cyclone; and in

* Fourth Memoir, Journal Asiatic Society, Vol. IX.

several other instances also it has been observed as well as the barometer to fluctuate very remarkably.

249. In a report from the office of the *Capitaine du Port* (Master Attendant) of Pondicherry, giving an account of the severe Cyclone of October 1842, (Eighth Memoir, Journal Asiatic Society, Vol. XII.) of which the centre passed over that place, and five or six ships foundered near the coast, it is said, that "from 2 to 5 in the afternoon, in the most violent part of the storm, *the oscillations of the mercury in the barometer were so apparent, that it rose and fell instantaneously two to three lines as though somebody had shaken the barometer.*" The calm took place between 5 and 6 P. M.

The fluctuations of the water barometer at the Royal Society's rooms, are described by Professors **Daniell** and **Barlow** as resembling, on the approach of and during bad weather, "the breathings of some huge animal." They amounted in one instance to 0.28, while those of the mercurial barometer at the same time were only 0.02.

250. **Kaemtz** (*Meteorology*, p. 316) says, speaking of the barometer during tempests,

"These changes (of air) are rarely brought about without agitation : the air moves with velocity, and tempests are the result. The barometer *oscillates* and falls rapidly and rises again in the same manner. These characteristic oscillations are made at short intervals, they are irregular and should be regarded as a consequence of the inequality of pressure that gives rise to the tempest. What we have said concerning winds, fully conforms this opinion ; continued tempests (for I am not speaking of those which last merely for a few minutes) *are almost always preceded by great barometric oscillations which as it were announce their approach.*"

251. Col. **Reid** p, 447, speaking of the Barbadoes Cyclone of 1839, says—

"During the hardest part of the gale several persons observed remarkable oscillations of the mercury in the tubes of the barometers."

In the log of the *Sophia Reid*, p. 89 of Col. **Reid's** work, is noted, at the approach of a Cyclone in the Gulf Stream,

"Mercury much agitated, and inclined to fall."

252. **Mr. Thom**, p. 184, says—

"It has been observed that the mercury in the tube is *in certain parts of the storm* subject to sudden oscillations within the space of a few minutes, or even a continued motion upward and downward is said to have taken place. As this occurs near the margin of the calm, or where the atmosphere begins to ascend in sudden and spiral gusts into the focal current at the point of minimum pressure, it is not at variance with the principle of a regular gradation in the descent and rise of the barometer."*

253. In my Third Memoir, Journal Asiatic Society, Vol. IX. in the log of the brig *Freak*, Captain **Smoult**, which vessel was near foundering in a Cyclone in the Bay of Bengal in April-May 1840, it is noted as the vessel approached the storm, and when the wind is marked as "strong breeze and threatening weather," "*barometer vibrating very much.*" The vessel was at this time at about 240 miles from the centre of the Cyclone, and I have estimated that the verge of the circle may have extended to within about 130 miles of her position at 1 P. M., when this remark was made. The entire fall of Capt. **Smoult's** Barometer was from 29.30 to 27.25.

In my Seventh Memoir (Journal Asiatic Society, Vol XI.) on the Calcutta hurricane of June 1842, Mr. **Willis'** note from Garden Reach, 5 miles W.S.W. of Calcutta speaking of the simpiesometer says, and this is at the approach of the centre. Simpiesometer, "*breathing as it were, or fluctuating with the blasts.*"

254. In an extract from the log of the ship *Tigris*, which vessel was caught in one of the small Tornado-like hurricanes of the "Hurricane Tract" (see p. 34 § 47) in the Indian Ocean, being in lat. 9° S. long. 83° East. (Track *ee.* upon our Chart,) Captain **Robinson** remarks,

"Wind blowing in tremendous squalls from W.S.W. to West, the barometer rising and falling the tenth of an inch before and after them."

255. In M. **Peron's** relation of the voyage of *Le Naturaliste* and *Le Geographe*, speaking of the winds and hurricanes at the Isle

* We may note here that the up-current as it is termed by Mr. **Espy**, is in this passage assumed as a fact; but no evidence has as yet been produced to show that it exists, and Mr. **Redfield's** theory accounts equally well for the fall of the barometer, see pp. 14,15 § 23,28.

of France, he says that the two most remarkable ones of modern years, (he was writing in 1801), were those of December 1786 and December 1789, in which the fall of the barometer exceeded an inch (English); and in the last storm it is noted that the oscillations extended through the space of two lines, (about 0.2 English) and that, "*Flashes of a pale light were evolved from the surface of the mercury that filled the whole vacuum of the tube.*"*

256. There is, then it will be seen, no sort of doubt of the existence of this oscillation, and we shall, I trust in future have it carefully observed and noted, and the seaman will readily understand how this may occur, and that it may be, and probably is, occasioned by the passage of successive waves of air, circular or straight, over the place of the instrument,† and that these waves may be more or less abrupt, and high, and gradual, according to a hundred modifications of the storm above. For him the practical fact is, the important truth that the barometer and simpiesometer if "uneasy" announce bad weather in the vicinity. The water barometer before alluded to, showed the effects of every successive gust of wind, which was in fact a wave of air passing over the spot.

257. Another sign of an approaching fall in the barometer, if not of a Cyclone which I have noted, is that *it does not rise* at the usual barometric tide hours, but remains stationary. When this occurs, there can be no doubt that some disturbance is going on somewhere, and the barometer and simpiesometer should be carefully watched.

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* Mr. **Peron** was a first rate naturalist and observer, and his name stands so high, that we may suppose he did not set down this very remarkable phœnomenon without fully satisfying himself by careful enquiry, that it had been observed and registered at the time by more than one person.

† If a syphon with a barometrical vacuum was fixed in the side of a diving-bell the outer branch being left open and the bend filled with mercury, the rise of the mercury in the inner branch would measure, proportionally, the depth to which the diving-bell sunk, and the pressure (i. e. weight) of water upon it. If a wave passed over the spot the mercury would rise for a moment and sink again, and so on successively as each wave passed. This is the oscillation of our barometers and simpiesometers which measure the depths and waves of air in the *ocean of air* in which we live, as the fish do in theirs of water.

258. *During a storm*, the most careless seaman, I presume, looks often at his barometer, and few if any require to be told that while it continues low, more bad weather must be looked for, *and this even if they have gone through all the phases of one Cyclone*, and their barometer has fallen at its onset, remained very low during its fury and the calm of the centre, and has gradually risen again *a little*; still, low sail* should not be made, for it is possible that there is another Cyclone close upon the one which has past.

259. This case of successive Cyclones following one upon the other, has occurred in repeated instances in both the East and West Indies, and off the coast of North America; or as in the case of the *Culloden's* Cyclone of 1809, as traced by Colonel **Reid**, the track being a curved one, the ships—in that case a fleet of them—after falling out of the storm circle on one side, ran again into it on a day or two afterwards, when it had curved back and again crossed their route homeward; but their barometers were always low in the interval: see p. 61 to 63, for what has been said on these various kinds of storms. In all such cases it is clear, that while the barometer and simpiesometer have not risen to their average height, and all other appearances have not become favourable, the seaman should still be on his guard. I say here "*all other appearances*," because we may suppose a case in which if two Cyclones approached each other at a wide angle, as was certainly the case in the *Golconda's* Cyclone before quoted, there might be a position in which for a time, and before the borders of the two were in contact, the barometer might be *driven* up, i. e. the two atmospheric waves might produce a considerable rise, though in such a case the weather would, as far as we can judge, be still gloomy and threatening enough. We have as yet no exact account of any vessel's barometer and simpiesometer, between two following or parallel Cyclones, though such cases must doubtless frequently have occurred. A good account of this kind, with careful barometrical observations, would be very valuable.

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* And, if not absolutely necessary, no square-sail should be set.

260. The ship *Eliza*, Captain **McCarthy**, whose able report is given at length in my Ninth Memoir, (Journal Asiatic Society, Vol. XII.), *appears** to have been a little after midnight on the 2nd and 3rd Oct. 1842, off the Sand Heads, not far from the point where two parallel storms were passing to the North and South of her, and one of them was a furious and almost destructive storm to her. Her log states, that, about this time "barometer fell very suddenly since midnight from 29.30. to 28.30! and simpiesometer (which before is marked at 29.22) to 28.22!"

261. **Rise of the Barometer and Simpiesometer before the strength of the Hurricane is over.** Seamen are well aware of, and anxiously look for this beautiful indication, which is often and truly, to them, a rainbow of hope in the depth of their distress. Mr. **Redfield** accounts for it by supposing that as the lower part of the whirling cylinder of the Cyclone, meets with resistance at the surface of the earth, it cannot advance so fast as the upper part, and thus the cylinder is not a truly perpendicular one, but more or less inclined in the direction of the track, just as we often see the cloud of a water-spout move on above, and the spout itself remain seemingly stationary below, so as to become sloping or curved. By means of the little experiment with the glass tumbler, described at p. 180, we can easily understand this, if we suppose the glass a little inclined over, and that the vortex was to remain at the centres above and below; for that part of it above will then have a less column (of water in the glass, and of air in the case of the Cyclone), between it and the paper, than that below, which is really the centre of the supposed Cyclone, as raging at the surface of the ocean, and the augmented column is an addition of *weight*, which consequently causes the rise of the mercury.

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* I speak with caution here, because though the *Eliza's* place is well ascertained, the position of the centres of the parallel Cyclones is not so exactly determined at this time as to enable me to speak with certainty. Nevertheless, this instance is the nearest example we have, and I will not therefore omit it.

262. In the Nautical Magazine for 1841, p. 726, in remarks on the winds and weather off the West Coast of Australia, already quoted, (p. 37) by Commander **Wickham**, of H. M. S. *Beagle*, it is remarked that, in two Cyclones which occurred between St. Paul's and Amsterdam, and Swan River, though of equal strength and duration, and both attended with heavy rain, the barometer in that "from the N.W." (it was N.N.W., veering to the Westward), the barometer fell nearly 6-10ths of an inch, while in that "from the South Eastward" (which appears not to have veered at all, as nothing is said of it), it only fell 0.25, and this appeared very unaccountable.* The solution of the difficulty will appear simple if the Horn Card be moved over the spot, which, approximately only, for I have not been able to obtain the exact position for these Cyclones, I have marked on Chart II. for it will at once be seen that, if the card be moved so as to take the N.N.W., and gradually the West wind-point over the spot, this places the ship *before* the track of the Cyclone while the centre passes close to the South of her; but with the South Eastern gale, she is *behind* it, and thus the fall is far less considerable. I have little doubt that many of the barometric anomalies of gales from different quarters causing different degrees of fall, will eventually be explained in this way.

263. **The Barometer as a measurer of the distance of ships from the centres.** This question is not an easy one; nor do I flatter myself, we shall completely resolve it. Nevertheless, its mere *examination* may throw much light on the mechanism of storms, and any guide, under due caution, is highly desirable to the mariner. I am, therefore, desirous, not so much of setting my own views forward, as of directing the attention of sailors *and of residents on shore, whose observations are the most valuable for the solution of it,*† to this infinitely important problem in our science.

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* The gales are quoted to show their different effects upon the barometer being from "opposite quarters," and such they seemed to be at the time.

† On account of their observing in fixed positions, and much more at leisure than sailors can do at sea; at least until we have vessels sent out for the purpose of investigating storms.

The question, briefly stated, is this—"*Assuming the nearly circular figure; the rotatory and progressive motions of Cyclones; and that some of them are at times stationary; and that there is a point of veering or a calm space, which we may call their centre—and all this is tolerably certain;—can the fall of the barometer, be made an approximate measure* of the distance of that centre, from us? or of its rate of approach to a ship or a station on shore? and can it be used as such both within and without the tropics?*"

264. I have suggested this question since 1845, (in the first Edition of the Horn Book of Storms for the Indian and China Sea, p. 11), and it had indeed engaged my attention since 1842, when I exhibited to the Asiatic Society of Bengal, at one of its meetings, a large Barometrical Chart of the curve formed in the storm of June of that year, which is the subject of my VIIth Memoir in its Journal. Mr. **Thom**, whose work was published in 1845, had also taken up this question without having seen my work; and he has given a plate of the range of the barometer during hurricanes, and a diagram on his chart of the approximate distances from the centre, by barometer, for the Cyclones of the Southern Indian Ocean. The fall in a given *time* he has not adverted to in the text, considering, probably, that time, and distance from the centre, must vary according to the rate of the Cyclone's travelling and distance. In the following remarks, I shall endeavour always to distinguish his views from my own, should they meet. I think the difference between our theories is, that he inclines to suppose the absolute (entire) fall as the best guide, and I prefer the *rate* of fall, though I would not neglect the entire amount, particularly where sudden.

265. And first, it is evident that there are very great differences in the fall of the barometer in various storms,† though they may all

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* For the plain seaman: "*a·proximate* measure," is a measure *approaching to*, and usually not far from a correct one.

† In one case (Sixth Memoir "Storms of the China Sea," Journal Asiatic Society, Vol. XI.), there is a remarkable instance of a furious tyfoon-cyclone in which the barometer of the ship *Ariel*, gave no warning, being at 30.10, falling to 29.80, and rising to 30.25, with the gale blowing as hard as ever, and at noon

be true Cyclones, and this in the same seas, so that the absolute (total) fall of the barometer, say of one, two or even more tenths may greatly mislead us, if we trust to that alone; for we may be supposing that "as the barometer has only fallen three-quarters, or one-tenth that is not so very much (from a height say of 29.80)" taking here no account of *the time in which this fall has occurred;* whereas with a fall of one or two tenths in a short time, we may be really close upon the dangerous centre, or a hurricane may be rapidly coming close down upon us. The seaman will clearly understand this by the consideration of the plate and what will be said of it.

266. Let us first consider our data, and the amount of their certainty or uncertainty with reference to our problem. I allow that the barometer is one which, if not correctly 'set,'* as it is phrased by sailors, is tolerably sensitive and acting well. The questions then are—

I. As to the Cyclones themselves.

First. Cyclones being in themselves of different intensities (strengths), i. e. causing the barometer to fall more or less at their centres, as seen in the plate; one Cyclone causing a total fall of one inch, and another of two and half or even more.

Secondly. Cyclones being of the same or of different *extent;* as one being 100 and another 400 miles in diameter; but both occasioning the same total amount of fall at the centre—say of one inch.

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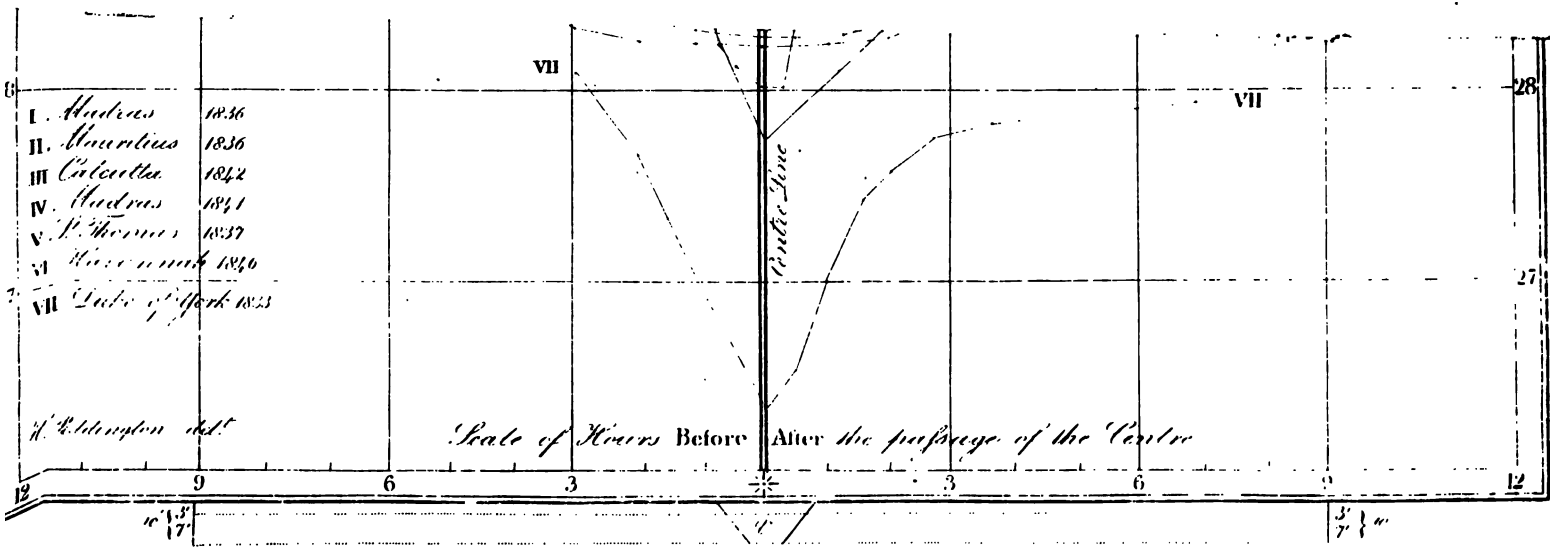
it was at 30.90. I ascertained from the (then) chief Officer of the ship, who subsequently commanded her, that the barometer was a good one, and had always acted well. I traced, however, two storms (Tracks XXV. on Chart No. II.) one coming from the N.E., and the other from E.S.E., and a heavy monsoon from N.E., blowing in from the Pacific at the same time, and it is to this that I attribute this remarkable instance. In the *Buccleugh's* cyclone also (Track n on Chart II.), the barometer fell only 0.24, *but the simpiesometer* 0.82. The *Ariel* had no simpiesometer. Mr. **Thom**, p. 177, who had not seen my Memoir, thought that "there is no well authenticated case of this kind on record," but I consider the *Ariel's* as one, and it is highly instructive.

* *Set.* i. e. The Zero point, or level of the mercury in the cistern or bag, too high or too low.



Storm Disks of 300 Miles in Diameter and from 7 to 3 miles in height

a Central Vortex of 10 miles calm at its base

or estimates; for even where the centre has reached the ship, all the observations must, it is clear, be heights of the barometer in *different places* in the area of the storm.

269. The instances in which the barometer has been accurately registered in places where the centre of the Cyclone has passed over the spot—and as just shewn, it is only those which will give us trustworthy data—are very few. They are laid down in the annexed Barometrical Chart, and I shall presently describe the principle upon which it is constructed.

The plate thus comprises.

			AUTHORITY.
I.	Madras Hurricane, ...	1836,	Observatory records.
II.	Mauritius, ...	1836,	Cols. **Lloyd Lewis; Reid.**
III.	Calcutta, ...	1842,	**H. Piddington,** 7th Memoir, Jour. As. Soc., Vol. VII.
IV.	St. Thomas', West Indies,	1837,	Professor **Dove** in Part. X. of Scientific Memoirs.
V.	Duke of York, Kedgeree mouth of the Hooghly,	1833,	Mr. **Jas. Prinsep,** Jour. As. Soc., Vol. IV. **Reid,** p. 291.
VI.	Havanah,.....	1846,	Bermuda Royal Gazette.
VII.	Madras, ...	1841,	Observatory Reports, 5th Memoir, Jour. As. Soc. Vol. VII.

270. The principle on which the diagram is constructed is, to take without reference to the hour of the day or night at which it occurs, the lowest point of the barometrical depression in a Cyclone, as the CENTRE or axis of that storm. This is placed on the double, or axis, lines || in the middle, and the fall and rise, and the time in which these occur, are shewn on a scale of hours below, and of inches to the right and left. We have thus the Cyclones brought together and *placed upon each other,* as it were, for comparison; under exactly equal conditions *as to time,* and as to the fall of the mercury in that time. The scale of miles above will be presently explained.

271. And we are immediately struck with the fact that there are evidently two distinct classes of Cyclones, in one of which the fall and rise are more or less gradual, forming an easy curve, while in the others it forms not so much a curve, but almost an angle* or rather the figures called by opticians caustic curves, and in these last Cyclones the fall has been excessive and the fury of the tempest far beyond the average of such visitations. We may thus divide the storms into a first and second class; the first class being those of the greatest (excessive), and sudden falls near the centre.

There is also evidently another peculiarity; i. e., that all the rapid part of the fall seems to begin at from three to six hours before the passage of the centre, and that before that time the fall even of the violent Cyclones, is comparatively gradual, and in fact approaches closely to the second class.

272. The following table explains itself by its title. It is calculated to the nearest third decimal from the authorities given, and arranged like the plate, of which it is in fact the measurements at the different hours.

As an hundreth of an inch may be worth notice in these calculations and estimates, and as this is easily missed in the measurement or the drawing, the copying of the plate, or the shrinking of the paper after the impression, I have extracted and calculated this table from the registries of the storms, calculating to the nearest decimal where the distance in time from the centre does not fall exactly at the hour of observation; and where the calm centre has lasted for any marked epoch of time, as we see it notably has in the plate, taking the middle of that interval of time as the central instant. The heads 2*h*. 3*h*. 4*h*. 6*h*. and 12*h*., signifying the *total* fall in that space of time *before* the passage of the centre; and the column of rate, that of the rate of fall per hour, *in the interval given at the heading only*, and not the total mean fall.

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* The two kinds of curves are compared by Professor **Dove**, of whose Memoir I have only access to brief abstracts, to deep ravines with precipitous sides, and to extensive vallies with gentle declivities.

Table of the fall of the Barometer, and of the Rate of fall per hour at various distances (in time), from 12 *hours before up to the passage of the Centre; to accompany the Barometrical Chart.*

No. in Plate.	Storm and Authority.	Mean falls between 12 h. and 6 h. from Centre.	Rate of fall per hour.	Mean falls at between 9 h. and 6 h. from Centre.	Rate of fall per hour.	Me an falls between 6 h. and 3 h. from Centre.	Mean rate of fall per hour.	Mean falls between 4 h. and 2 h. from Centre.	Mean rate of fall per hour.	Mean falls between 3 h. and Centre.	Mean rate of fall per hour.	Mean falls between 2 h. and Centre.	Mean rate of fall per hour.	Remarks.
		In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	
I.	Madras, Oct. 1836. Observatory Records, ...	0.157	0.026	0.319	0.106	0.454	0.151	0.422	0.211	0.715	0.238	0.473	0.236	
II.	Mauritius of March 1836. Col. **Reid**, p. 175,.....	0.500	0.083	0.345	0.115	0.445	0.148	0.225	0.112	0.100	0.033	0.015	0.007	Lowest depression before the calm.
III.	Calcutta, June 1842. **H. P.**, J. A. S., Vol. XI.,.....	0.120	0.020	0.048	0.016	0.434	0.145	0.392	0.196	0.286	0.095	0.083	0.041	
IV.	Madras, May 1841. Observatory Records, ...	.....	.....	.....	.....	0.135	0.044	0.098	0.049	0.301	0.100	0.234	0.117	No registry, 12 h. to 6 h.
	Means of Nos. I. to IV.,...	0.259	0.043	0.237	0.079	0.467	0.147	0.284	0.142	0.350	0.116	0.201	0.100	
V.	St. Thomas and Porto Rico, August 1837. Professor **Dove**, Part X. Scientific Memoirs, ...	.....	.....	.....	.....	0.265	0.088	0.467	0.233	1.481	0.494	1.237	0.618	No registry, 12 h. to 6 h.
VI.	*Duke of York's* Hurricane, Kedgeree, 1833. Mr. **Prinsep**, as quoted by Col. **Reid**, and J. A. S.,	.....	.....	.....	.....	.....	.....	.....	.....	3.600	1.200	2.370	1.180	No other registry.
VII.	Havanah Storm of Oct. 1846. Bermuda Royal Gazette Oct. 20th 1846,	0.440	0.077	0.190	0.063	0.310	0.103	0.580	0.290	1.190	0.397	0.980	0.490	
	Means of Nos. V. to VII.,	0.440	0.077	0.190	0.063	0.287	0.095	0.523	0.261	2.090	0.697	1.529	0.763	

273. If we look at the mean fall for the *two* hours before the centre, (or from ‖ to 2*h*, towards the left hand, in the Plate) in the Cyclones of the first class, V. VI. and VII., we shall find it to be as much as 1.529 for the whole two hours, or 0.763 per hour, while those of the second class give but 0.201 for these two hours, or 0.100 per hour!

Again at 3 hours from the centre we have,

	Total fall.	*Mean rate per hour.*
First Class,	2.090	0.697
Second Class,	0.350	0.116

And at from two to four hours from the centre it is,

	Total fall.	*Mean rate per hour.*
First Class,	0.523	0.261
Second Class,	0.284	0.142

It is evident then that, taking into account also the differences of rates of travelling,* which might occur in Cyclones of exactly the same intensity, these two classes are, at least towards their centre, so different, that no common rule can apply to them.

274. The examples of the plate and tables are, as I have already noticed, necessarily from registries of Cyclones on shore, but there is also no doubt in my mind that this distinction, of the sudden and excessive falls near the centres, which constitutes our two classes, exists also at sea; where in those hurricanes (Cyclones) from which ships have but barely escaped from the centre, we usually find this kind of fall. As intances of this, I may quote the following.

The H. C. War Steamer *Pluto*, in the China Sea—nearly foundered (see pp. 39, 75)—Bar. fell in all from 29.90 to 27.55 or 2.35 ins. and in the last three hours about 1.25 of this fall occurred while steaming and drifting into the centre.

The transport *Briton* in the Cyclone in the Andaman Sea, in which with the *Runnimede*, she was lost on the Andaman Islands, (see pp. 39, 75) appears to have had a fall of about 1-0 inch or more

* We do not know what the rates of travelling of any of these Cyclones were, except No. III. It is possible that the more rapid falls of some may have been occasioned by their quick approach, but the two classes seem essentially different in so many respects that I treat them as such, at least up to four hours, counting from the centre.

of her simpiesometer within the three hours of her being at the centre, and of about 2.30 ins. in all; and in this storm the force of the wind was so terrific that it was tearing up the front of the poop in both ships!

The ship *London* in the Bay of Bengal, quoted by Col. **Reid**, p. 291, from the Journal of the Asiatic Society, had a fall from 29.70 to 27.80 or 1.90, of which one inch took place within the last four hours.

More instances may be adduced, but these will be quite sufficient to shew that the peculiarity of an excessive fall in about three hours, (of time or distance), preceding the passage of the centre, takes place at sea, as on shore, with the Cyclones of one peculiar class.

275. But we may also say that, generally speaking, the seaman, fortunately, does not require, or very rarely so, to know what we are now discussing; for when once so far involved in the Cyclone as to be within four hours (of time) of its centre reaching him; or at from 50 to 60 miles allowing it an average rate, he has probably but little choice of manœuvreing left him.

What he wants is, a rule to serve him as some sort of a guide at the approach and beginning of the storm, when his plan of management, as explained at p. 90, may depend on his estimate of the distance of the centre from him. We shall now see that, at greater distances, the fall for both classes of Cyclones is so nearly the same, that we may, *so far as our present knowledge extends*, deduce some useful hints at least from the barometer in this respect; if we cannot fairly and safely trust entirely to it or call it *a measurer* of the distance from the centre?

276. For it is evident both from the plate and table, that, at from 6*h*. to 3*h*. from the centre, we have a mean fall,

For the First class of, ...	0.095 per hour.
For the Second class, of,.....	0.147
The mean of these two being	0.121

and with the exception of the Madras storm of 1841, No. IV., this mean is near enough to each separate instance, to guide us, and to admit of its adoption for our purpose.

At from 6*h*. to 9*h*. distance from the Centre, the means are—

First Class, ...	0.063	One instance only.
Second Class, ...	0.079	
Mean of this,.....	0.071	

At from 6*h*. to 12*h*. distance from the centre, the means are—

First Class, ...	0.077	per hour.
Second Class, ...	0.043	,,
And the Mean of these is	0.060	

But as we have only one registry for the storms of the first class, we shall perhaps be safe in taking 0.050 as a mean fall for this interval.

277. So far then as to the mean fall *in time ;* but the sailor requires this in distance for his purposes, and we have seen (p. 192) that time and distance can replace each other according to the rate of the Cyclone's travelling. We can only then affix an arbitrary distance,* and then try how far our rules wonld have shown correct results in actual cases, where we have the rate of fall for any fair average of hours, and can calculate nearly enough for all practical purposes the actual distance of the centre from the ship. The seaman will clearly understand, I hope, that what I mean to express here is, that while it may be at least worth his masts to him to know if he is at 200, 150 or 100 miles distance from the centre ; it is of little or no use, generally, for him to know if he is at 50, or 80 miles from it ; for he has probably room, time, and weather to manœuvre in the first case, and in the latter has little or none of these, and must therefore confine his care to getting out of the way of the centre, or allowing it to pass with the fewest chances of damage to his ship. When the centre is within 50 miles (or say three hours) of him, the Cyclone is pretty nearly master. What human skill can accomplish must be done before that time.

* I do not do this by mere guess, but after much consideration, and all the calculation which the imperfect elements afford of *about* what the distances have really been at the times, as will be subsequently shewn in a table.

278. The scale then which, after much consideration, I have found the nearest to the probable truth, is that marked in miles on the upper part of the plate, though this is to be considered as by no means strictly a limit; for as regards limits, I repeat that it may possibly be found in the end that there *are* no strict ones at all; and that even the various extremes may be wider apart than the following table will indicate—

An average fall of the Barometer per hour of			*Shews the distance of the Centre from the ship to be in miles*			*Remarks.*
FROM		TO	FROM		TO	
0.020	.....	0.060	250	.....	150	The third decimal of the Barometer heights is replaced by a cipher.*
0.060	.....	0.080	150	.....	100	
0.080	.....	0.120	100	.....	80	
0.120	.....	0.150	80	.....	50	

I have not set down any thing for the centre division of our table, i. e. from the centre to 3*h*. before its passage, for it will be seen that the rate of fall per hour doubles after the Cyclone has fairly began and lasted six hours; and that then (from 3 to ‖ or from nine hours after the commencement up to the centre), it may either continue to fall at the same rate of *about* 0.1 per hour or a little more, or that its rate of fall per hour may be, if it should be a Cyclone of the first class, as 100 to 400, when compared with that of the former three hours; or in other words, that it will now begin to fall *four* times as fast, or 0.40 per hour!† We

* For we must always bear in mind errors of observers and instruments, and, except perhaps in Observatory registers, allow something for weather in which doors, windows and roofs are shaking hard to fly out of their frames. I trust also that both the seaman and the scientific reader will make large allowances for the exceeding scantiness of our materials. If we had *seventy* sets of averages in lieu of only seven, we might see our way clearly at once; and indeed, I have at times felt doubtful if it was not yet too soon to publish this investigation, but have been led to do so by the hope that the sailor may be doubly served by it; for it may perhaps assist him, and it will no doubt obtain for us more materials—and perhaps better workmen with them than myself?

† The plain seaman must be very careful in reading all this to pay attention to the values of the decimals, and not confound the tenths with the hundredths.

have plenty of instances of this, and even of a fall of more than 0.5 or 0.75 (half or three-quarters of an inch) in the hour! I doubt not that this peculiarity will fully account to the seaman for, and I hope put him well on his guard against, cases of sudden falls; which if they occur at the beginning of Cyclones, as they sometimes do, are warning enough of course; but which may also advise him of his too near approach to danger of such imminence that we may at least say that no ship can hope to escape from it with her masts standing; and he should in such cases have the axes upon deck: a precaution too often neglected by young commanders and officers, who are apt to suppose that precaution indicates fear—and they *are* sometimes afraid of being *thought afraid* of the storm.

It will be remembered also, that it is quite impossible by any previous rates of fall to estimate, when so near the centre, which of the *classes* of storms we have to deal with; and I repeat that what we have to do with our ship must all be done before this time.

279. But before applying this rule we must recollect that there are many circumstances to which attention is to be paid, and the best precepts I can at present give for the application of it are the following. If I make these minute, and encumber them as some may think with "considerations," it is because I will not set down anything as positive which is not so, or on which the smallest doubt may remain; and because I should much regret that any one should be led to suppose, for want of explanation, that he had an infallible *Law*, when he has only an empirical rule.*

1. The barometer at the approach of bad weather, should be observed carefully every hour, and especially at night. If every *half* hour so much the better: and it should be entered immediately on the log.

2. At the end of every two or three hours, *the rate of fall per hour*, should be carefully averaged to the nearest decimal.

3. It should then be considered, if the barometer has *not risen* at the usual times of its tides,† or if the interval of the falling tide,

* A rule founded partly on facts and partly on assumptions.

† I need not explain to any sailor, I hope, the *tides* of the barometer, and the importance of noting if any thing affects these.

or any period of it has formed a part of the time elapsed, or if it should in this interval have risen. In both cases an allowance should be made for this at the onset of a storm; for or against, as may be. Thus

From 11 P. M to 2 A. M., are 3 hours.

Total fall of barometer, ...	0.18
Which is per hour, ...	0.06

But as this is within the falling barometer tide-time, and the whole fall is not yet considerable, we may call the fall, about, ... 0.05

and this sort of allowance is exactly what the sailor makes when working up his log in a tide's-way.

4. As the ship's run, and the probable bearing of the centre are known, and as, if it is one, the average track of the Cyclone may also be known in many places, it should be considered if the ship has been approaching it or increasing her distance from it, as this would also affect the fall.

5. The application of our rule depends not only on the fall, for the last hour for instance, but on the *rate* of falling. Nevertheless, the seaman will easily understand, after he has made his best estimate, that if latterly the barometer has fallen at an increasing rate, he may be farther on (to the right hand or towards the || of the centres) upon the curve, than he supposes; and the careful man will always keep on the safe side, and make that sort of allowance, which he does for excessive tides or currents in the neighbourhood of dangerous passages.

6. As will be seen in the Notes to the Table, the vicinity of land certainly affects the indications of the barometer, whether the storm be supposed to be advancing toward, or coming from, or passing by it, and this should always be borne in mind.

7. The trades and heavy monsoons also appear to affect the state of the barometer, at least on that side of the storm circle on which they blow, whether with or against its track; but we require

more data before we can say how and under what circumstances this occurs.

280. I proceed to shew in the following table by actual examples, carefully calculated, what the results of the foregoing rule would have given, if it had been used in the storms and on board the ships they refer to.*

The columns of this table require some explanation.

I., II., III., and IV. explain themselves, as being Number, Date of storm cited, Ship or station, and Authority from which the data are taken.

V. Is the Average *rate* of fall of the barometer per hour.

VI. Shews the Number of hours, for which this average has been taken.

VII. Shews the Distance which would be given by the rule *at the beginning and end of the time, for which the average is taken*: Thus if we refer to the table, at p. 199, we shall see that a fall of 0.1 one-tenth, per hour, gives a distance of 135 miles to 45 miles; that is, that it would indicate at the first hour 135 miles of distance, in two hours 105, and in three 75 and so on, reading the table backwards as it were, or diminishing the estimate of the distance as the fall has lasted a longer or shorter time, so as to obtain an approximation to the actual distance at the time of making the last observation and the calculation for it.

VIII. Mean distance by rule: is the distance of the centre of the storm at the *mean* time between the observations quoted. Thus, suppose observations from Noon to 4 P. M. give an *average* fall of 0.080, this will give a distance of 125 miles *at* 2 *p. m.*

* These examples are not selected partially, but I have taken every one I could meet with which affords the elements necessary, viz. good barometrical observations, with the place of the observer and that of the centres of the storms for two days as accurately determined as could reasonably be expected. But it is rare to find all these present, and the want of any one of them debars us from using the instance as a fair test.

This column is necessary, because the fall, for instance from 3 to 4, may have been more rapid, or was not observed. If it was observed, this would shew that the centre and ship were approaching rapidly, and the next hour's average, *with* this one, or that from 3 to 5, will demonstrate this. If it was *not* observed, it is clear that it *may* have been more rapid, (since for example the weather looks more threatening and the squalls are heavier?) and the careful seaman will then suspect directly, that though at 2 P. M., he *was* at 125 miles distance, or thereabouts from the centre, yet it may be coming fast upon him, and the next hour as before, will shew a much greater fall and consequently a greatly reduced distance. In a word, the whole time of the approach of a Cyclone should be a contest between the vigilance of the seaman and the vagaries of the winds and the waves.

281. We should also in fairness remark that the want of regular horary observations in the instances at sea, place us in an unfair position for testing the accuracy of our rule; for we must at present take intervals of from 2 to 24 hours, and assume the mean as the time of the mean fall, which for 2 hours is well enough, but if we come to 4 or 6 hours it may much mislead us. Thus we may say that—

From	8 to 9	the fall is	0.01	or	0.02
„	9 to 10	„	0.02	or	0.03
„	10 to 11	„	0.03	or	0.04
„	11 to 12	„	0.04	or	0.05

or something of this sort.

Now as above said, if we have only observed at 8 and 12, we shall say that the mean fall was 0.025 or 0.038 at 10 A. M., but if we look at that between 10 and 12, we shall call it 0.035 or 0.045, and if we went on thus to 2 or 4 P. M., we should still be undervaluing the rate of falling, and consequently under-estimating our distances. Hence we may, especially where the true interval is large, suppose that the rule might give a nearer approximation if we had had more observations.

282. In considering the table, also, the seaman will upon reflection find it *much nearer to correctness in its result than it appears to be!* For he must recollect that, what he usually does is probably to look at his barometer and take the average fall for say 4 hours, and then, as I have done,* estimate that at 2 hours, (the mean time) it was at a mean distance.

But he should bear in mind, that either because the time of the usual rise has intervened in the latter part of his observations, or from any other cause, the fall has been *less* than it probably would be; or that the ship in scudding one way and the storm the other to meet her, have approached each other with excessive rapidity, and that he will in the next, — as he may have had in the last hour or two — have a much greater fall; though this has not been yet observed; so that, really the highest distance given by the limits was nearest to the true distance of the centre in the early part of the averaged hours. Thus if from 12 to 4 A. M., we say that the fall has been 0.050 per hour, this gives between 250 and 150, or an average of 200 miles at 2 A. M., but possibly, had the barometer been observed it would have given this average also, between 12 and 1, or say *at* 1 A. M., and that from 3 to 4 the fall was such as to place the limits of distance between 100 and 150.

Hence, as above said, our table *may* be more correct than it at first sight appears, or, at all events, with careful observations the rule may serve the mariner for all that he requires better than it promises to do.

283. I should remark finally on the following table, in reference to the care taken to construct it with fairness, that it has been difficult to use the rule in some cases in which readers who are acquainted with my Memoirs would naturally look for an example: thus, No. III. on the plate, is the curve of the Calcutta Cyclone of 1842, and yet I have not given any example from that storm. This is because,

* For want of hourly observations.

as will be seen in the Memoir, though we have a very good series of barometrical observations at Calcutta, which are moreover my own, yet we have only the log of one vessel to settle the position of its centre at noon the preceding day; and this may therefore be very uncertain; added to which the Cyclone itself was perhaps not fully formed when it passed her.

284. Another remark that I should make is, that I have mostly taken the instances at the time the sailor requires them, or that represented by the interval between 12*h*. and 6*h*. on our plate, and the reason of this will be evident, by referring to § 276 p. 197 and to the fact that (§ 274 p. 196) the rule becomes none at all when the centre is too nearly approached. On this last account also, I have often omitted what are at first sight good examples, but in which, upon consideration, it will be seen that though the one height of the barometer is given at a proper time for our purpose, and the distance of the vessel or station is perfectly well ascertained at both, yet the next observation for the average is so close to the centre, (and sometimes *in* it), that it would give no fair criterion of the average fall in the interval for the reasons already given.

Table shewing the results given by the Rule at page 199 *for the Barometer, when applied*

I. Number.	II. Date.	III. Ship or Station.	IV. Authority.	V. Average fall of Barometer per hour.	VI. For how many hours average taken.
				Ins.	*h.* ′
1	28th and 29th Sept. 1840, ...	*Flowers of Ugie*, Bay of Bengal,	**H. Piddington**, IIId Memoir, ...	0.13	7.00
2	16th May 1841,	Madras Observatory, ...	**H. P.** Vth Memoir, ...	0.054	1.00
3	———	———	———	0.080	2.00
4	23d Octr. 1842,	*Sarah*, Bay of Bengal, ...	**H. P.** VIIIth Memoir, ...	0.020	5.00
5	....	Madras Observatory, ...	.....	0.030	2.00
6	....	Ryacottah Observatory, ...	.....	0.018	15.30
7	21st May 1843,	Barque *Teazer*, Bay of Bengal,	**H. P.** Xth Memoir, ...	0.075	4.00
8	21st & 22d May 1843, ...	Barque *Candahar*, Bay of Bengal, ...	.....	0.030	24.00
9	....	Masulipatam, ...	.....	0.082	2.30
10	....	Ship *Genl. Kydd*, off Madras, ...	.....	0.013	24.00
11	27th Novr. 1843,	Ship *Futtle Rozack*, S. Indian Ocean, ...	**H. P.** XIth Memoir, ...	0.054	4.30
12	28th and 29th Novr. 1843,...	*John Fleming*, S. Indian Ocean,	.....	0.033	24.00
13	Sept. 3d 1842, ...	Barque *Wm. Engs*, Gulf of Florida, ...	Mr. **Redfield**, Am. Jour. of Science, Jan. 1846, p. 8, ...	0.050	8.00

estimating the distance of the centre by the average fall of to actual cases at Sea.

VII.	VIII.	IX.	X.	XI.		
Distances from centre given by the Rule.	Mean of distances by the Rule.	Actual distances from the centre measured by Chart.	Mean actual distance.	Rule + of true distance.	Rule − of true distance.	Remarks.
Miles.						
100 to 50	75	180 to 20	100	—	25	Cyclone and ship approaching each other.
100 to 150	125	90	90	35	—	Cyclone not violent, no Ships lost, No. 3 too near the centre.
100 to 80	90	90 to 70	80	10	—	
250 to 150	200	170 to 145	157	43	—	Ship on the verge of the Cyclone.
250 to 150	200	80 to 60	70	130*	—	See Remarks (1.)
250 to 150	200	198 to 65	131	69	—	An Inland Report from Surveyor General of S. India.
150 to 100	125	152 to 88	120	5	—	Ship and Cyclone approaching each other very rapidly.
250 to 150	200	100 to 280	190	10	—	
80 to 100	90	82 to 104	93	—	3	A shore observation, but locality flat.
250 to 150	200	295 to 80	187	13	—	
250 to 150	200	87 to 70	79	121	—	†
250 to 150	200	37 to 83	60	140	—	Position uncertain.‡ — See Remarks (2.)
250 to 150	200	.....	200?	—	—	Place of centre not very well ascertained, but nearly at this distance.

I.	II.	III.	IV.	V.	VI.
Number.	Date.	Ship or Station.	Authority.	Average fall of Barometer per hour.	For how many hours average taken.
				Ins.	*h.* ′
14	Octr. 5th 1844,..	*Key West*, Gulf of Florida, ...	Mr. **W. C. Redfield** Am. Jour. of Science 1846, p. 342, Cuba Hurricane, ...	0.048	13.00
—	———	———	**W. C. R.**	0.079	4.00
—	———	———	....	0.082	4.00
15	Octr. 6th 1844,	*U. S. B. Pioneer*,	..... p. 346, ...	0.04	4.0
16	Octr. 7th 1844,	H. M. S. *Illustrious*, Halifax Harbour, ...	..... p. 356, ...	0.05	4.0
17	———	———	....	0.06	4.0
18	———	H. M. S. *Pique*, Coast of Cape Breton,.....	..... p. 357,	0.05	4.0
19	———	———	.....	0.07	3.0
20	4th and 5th April 1843, ...	Barque *Blanche*, South Indian Ocean, ...	Mr. **Thom**, p. 305 and 37, ...	0.01	24.0

VII.	VIII.	IX.	X.	XI.		Remarks.
Distances from centre given by the Rule.	Mean of distances by the Rule.	Actual distances from the centre measured by Chart.	Mean actual distance.	Rule + / — of true distance.		
Miles.						
250 to 150	200	.....	300	—	100	Cyclone crossing the Island of Cuba (3.)
150 to 100	25	.....	180	—	55	
100 to 60	90	.....	158	—	68	
250 to 150	200	.....	228	—	28	
250 to 150	200	350 to 288	319	—	119	See Remarks (4).
250 to 150	200	345 to 240	292	—	92	
250 to 150	200	290 to 190	240*	—	40	See Remarks (5).
150 to 100	125	.....	120*	5	—	Mr. **Redfield's** estimate of Ship running for the Gut of Canso. But he states p. 165, that the centre of 7th should be placed 30′ further in advance, which would make these Nos. 210 and 125.
250 to 150	200	180 to 130	155	45	—	Ship to S. E. and S. of Cyclone in the S. E. trade.

NOTES AND REMARKS ON THE FOREGOING TABLE.

285. Some of the instances here given appear to contradict the rates we have taken as guides. They are however as authentic as other instances, and I have set them down as what are called, in researches on questions of Natural Philosophy *outstanding instances*:* or instances which for the present do not agree with the rule given, but which should be registered if thought correct as they often lead to new discoveries and laws. I note, in the order in which they are numbered, these exceptional cases.

(1.) No. 5. Madras Observatory. The average fall here would give 200 miles of distance, while the centre of the Cyclone was really at about 70 miles only. The track of the storm is one coming in directly towards the shore, and the outer verge of it may have been so far influenced by the Pulicat Hills, behind Madras, as to have diminished the fall of the barometer; and this appears the more probable, that in the same Cyclone the result shewn by the *Sarah*, No. 4, in the open ocean, though on the extreme verge of the storm is a very fair one. That by the Ryacottah Observatory, No. 6, though completely inland and subject there to many irregularities between the great chains of the Eastern and Western ghats, is also as fair a result as can be expected.†

(2.) These two instances, *Futtle Rozack* and *John Fleming*, Nos. 11 and 12, are wholly outstanding ones, but with the exception of the Note at No. 12, explaining that the *Fleming's* position was uncertain on that day, I have no reason to doubt that the instance, at least in the case of the *Fattle Rozack* is a correct one as to data, and tolerably so as to that vessel's position.

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* Herschell's Discourse on the Study of Natural Philosophy.

† The same anomaly occurs in applying our rule to a case on the coast of Ceylon, in the log of the P. and O. Co.'s Steamer *Hindostan*, Capt. Moresby, (XIV. Memoir Journal Asiatic Society's Vol. XIV.), in which that vessel steamed through the centre of a Cyclone, coming up from the E.b.S., and striking the (North and South) shores of Ceylon. By the average fall of the *Hindostan's* Bar. (within 10 or 15 miles of the shore), the distance of the centre would have been at 4 P. M., 1st December at 200 miles distance, but it really was not at more than 70 miles from her.

But this storm (Cyclone) was a very remarkable one, for while it was raging to the South of the Equator, another, which was probably forming on the 27th, was blowing on the North side of it in about the same latitude North, and not far from the same meridian; and between the two, along the Equator, a heavy North Westerly and Westerly monsoon was blowing. All these causes together may have influenced the barometer so far as to occasion a considerable diminution of its usual fall. The Cyclone also was a very slow moving one, and we do not yet know if these almost stationary storms are subject to exactly the same laws in this respect as those which have moved onwards from the first, or gradually acquired their usual progressive rates.

(3.) These three instances are very instructive, for this Cyclone at the time of the observations was forcing its way over the lofty mountains of Cuba, as its centre crossed that island, to travel up between the Bahamas and Florida, and the observations were taken at Key West about 118 miles to the left (Westward) of the track. Its centre at noon of the 5th,—and our latest averages extend only to 6 A. M., of that day,—had but just cleared the North coast of Cuba. The great differences are evidently owing to the irregularities of the pressure, and this view derives much corroboration from the fact, that as the front of the storm was clearing the island and reaching the ocean, from 6 A. M. to 11 A. M., there were evidently, though the gale was then in full force, very marked barometrical waves, as follows, viz.—

6 A. M.	29.402	
		— .067
7 „	.335	
		+ .083
8 „	.418	
		+ .118
9 „	.536	
		— .205
10 „	.331	
		+ .059
11 „	.272	

with, then, a gradual fall to 2 P. M., when the depression was 29.134 the lowest. The rise was not subject to these waves, but I do not in any case calculate from it. This instance is a full proof, that as has been said, the vicinity of land influences the effect of the storm on the barometer. The next is also a proof of it.

(4.) Nos. 16 and 17, H. M. S. *Illustrious*, lying in Halifax harbour, during the passage of the great Cuba Cyclone of October 1844.

The centre of this hurricane passed within 130 miles to the East of the harbour, at noon on the 7th, on a N.E. track, but the left hand portions of it were affected doubtless by the hills of the Nova Scotia coast, for the barometer of the U. S. brig *Pioneer*, No. 15, gave, as will be seen, correct approximations on the seaward side of the same storm circle.

(5.) These two instances are also very notable, for between the storm and the ship was at first interposed the high lands of Cape Breton and Nova Scotia, the ship being at the Northern entrance of the Gut of Canso, and in the second instance she was running in for it. Accordingly we find the following barometric waves marked between noon of the 6th and 8 A. M. of the 7th, when the regular fall takes place to 3 P. M. of the 7th (29.19) which was the minimum hour.

Noon	6 A. M.	29.65
		+ 10
3 P. M.	——	.75
		+ 15
8 P. M.	——	.90
		— 27
7 A. M.	——	.63

We may remark also of this, as of so many other instances, that had it been a case in which a ship was lying in an open roadstead, or bay, and the Captain had desired to put to sea, he would have had by the wind and average fall of his barometer, a sufficiently correct notice of the bearing and distance of the centre to guide his course in safety, so as to do the best he could to avoid the centre, or profit by the gale; which is practically all that we desire. Mr. **Redfield's** corrected review of the position of the centre, I have noticed in the remarks. Our result would by it approach much nearer to exactness.

(6.) I have noted here that "the ship was to the S. E. and S. of the storm in the S. E. trade," because I think it probable that a stormy trade or monsoon, rising as they often do to the strength of a gale, may influence the barometer so far as, on that side of the Cyclone towards which they blow, to diminish the total amount of fall, and consequently the average *rate* of fall; so that in such cases we shall find the distance given by the rule to be always too large. This instance, moreover, is one giving us only a 24 hours average with a total fall of 0.23, which for anything we know may have occurred with the last six or four hours. The rates of fall of the following days are however exceedingly small for a vessel so close in with the centre. Mr. **Thom** has given, at p. 181, a table of the barometer of the *Velore*, which is altogether an exceptional instance from our rule, and which, if there be no misprint, is very remarkable; for it would seem that she had from the 1st to the 4th of the month, a regular fall of 0.10 in the twenty-four hours while running before the gale, and this would give but a rate of fall of 0.004 per hour, though from the diagrams she seems to have been at from 120 to 160 miles of distance only. This anomaly probably arises in some way from the effect of the trade wind, but it is impossible in the present state of our knowledge to do more than conjecture vaguely as to the causes of this remarkable difference from the result of the test by the log of the *Blanche*. We must leave this notice for further investigation; observing, by the way, that the *Velore* was during part of the time close in with the Island of Rodriguez, though one would not, *a priori*, suppose that this mere speck in the ocean could have influenced her barometer. We unfortunately have no other registers from the numerous logs given by Mr. **Thom** to aid us in forming any sort of judgment. This anomaly occurs again in a very remarkable instance, that of the *Buccleugh's* hurricane, in which it is remarked in an extract from her log now before me.

"It is surprising that previous to so severe a gale a greater fall of the barometer had not taken place, having not been lower than 29·76 inches. It may be accounted for from the wind blowing from the Southward. The Simpiesometer had been for the last week about 38 decimals (0.38, is meant)

lower than the barometer, but on the morning of the gale it fell 82 decimals lower than the latter, therefore the indications of this sensitive instrument ought to be attended to."

In this instance also, as in that of the *Blanche* and *Velore*, the barometer of the *Asia*, quoted by Mr. **Thom**, seems to have indicated by a fall of 1.25 in 48 hours, or .018 an hour, the vicinity of the storm with tolerable correctness, but we are too uncertain of the position of the centre, and the barometer is given at too great intervals of time, to admit of our using this instance as a test of our rule.

286. **Excessive falls of the Barometer.** In reference to what has been said of excessive falls of the barometer, the following table collects instances of them where they have amounted to an inch and a half, or more.* Falls of an inch, and of an inch and a quarter are by no means so uncommon as might be supposed; and it is not I think improbable that, as our knowledge progresses, this remarkable distinction of Cyclones of the same intensity (so far as we can judge from descriptions, and from the damage sustained by well managed and well found ships) occurring sometimes with moderate and sometimes with excessive falls of the barometer, may lead us to some new views.

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* I have omitted amongst these that of the barometer of Admiral **Krusenstern** on the Coast of Japan in 1804, because the account in the Chinese Repository for 1839, quoted in my Notes on the Law of Storms, written for the use of the China Expedition, does not give the necessary data for ascertaining the amount of fall; which however was probably more than 2 inches.

Table of instances of excessive falls of the Barometer.

Storm and Locality.	Fall of Barometer. From.	Fall of Barometer. To.	Total Fall.	Authority and Remarks.
H. C. Ship *Duke of York*, Kedgeree, 1833, ...	29.9	26.30	2.70	Col. **Reid** and Journal Asiatic Society: may have fallen more.
Ship *John O'Gaunt*, China Sea, 1846, ...	29.65	27.50	2.15	Log, from Mr. **Elliott**, R. N. Master H. M. S. *Agincourt.*
Brig *Freak*, Bay of Bengal, 1840, ...	29.30	27.25	2.05	Log, Captain **Smoult.**
Ship *Exmouth*, S. Indian Ocean, 1846, ...	29.00	27.00	2.00	Mr. **Thom** and **H. P.** copy of Log, mercury disappeared, exact fall uncertain.
Havannah, 1846, ...	29.68	27.74	1.94	Bermuda paper.
Ship *London*, Bay of Bengal, 1832, ...	29.70	27.80	1.90	Col. **Reid**, p. 291.
Ship *Ann*, China Sea, 1846,.....	29.90	28.5	1.85	Mean of 2 Barometers, Log from Mr. **Elliott**, R. N., Barometer fell 0.3 in 50 minutes.
Mauritius, 1824, ...	29.93	28.23	1.70	Col. **Reid**, p. 167.
St. Thomas and Porto Rico, 1837,.....	29.76	28.07	1.69	Professor **Dove** in **Taylor's** Scient. Mem. Part X.: reduced to English measures.
H. C. S. *Neptune* and *Scaleby Castle*, 1809, China Sea, ...	29.85	28.30	1.55	**Horsburgh**, p. 289, **H. P.** VI. Memoir, Logs from E. I. Company; H. C. S *True Briton* foundered.
Port Louis, Mauritius, 1819, ...	29.50	28.00	1.50	Col. **Reid**, p. 161.
Brig *Mary*, W. Indies; Gulf Stream, 1837,...	29.60	28.10	1.50	Col. **Reid**, p. 96.

287. **Height of Storms above the surface of the Ocean.** The height to which storms extend is always a question of interest. We do not, as yet, know that if we were exactly acquainted with this element of our science, we could apply it to any useful purpose, but it is possible that it may turn to account some day or other.

Meteorologists are much divided as to the height to which clouds ascend, and **M. Peltier,*** whose work I shall presently allude to more in detail, shews satisfactorily, that there are two kinds of clouds; the common fog-clouds (as they might be called) and *transparent* clouds! or bodies of air loaded with moisture at a different temperature from the surrounding atmosphere, which are not yet condensed into vapour (fog) so as to be visible to us as clouds, but which nevertheless may be subject to, and produce all the phœnomena of visible clouds, though in a different electrical state.

What I speak of here, however,—and till our science has made much more progress, we must always, for practical ends, speak thus —is to be understood as applying only to the height of the cloud-portion of the cyclone, or what one might call the height of the storm-bank of clouds (see the next section) above the sea.

288. **Kaemtz** (pp. 365 and 366, English translation) says that *thunder* storms have been seen to pass above the summit of Mount Blanc (15,680 feet,) and he continues, speaking always of course of thunder-storms only, to say,

"It is sometimes possible to determine approximatively the height of a storm. When lightnings pursue a horizontal course we measure the interval separating the thunder and the lightning; now, as sound travels 333 metres (2,092 feet English) in a second,† we have only to multiply by 333 the number of seconds that have elapsed, in order to estimate the distance of the lightning from the observer. If at the same time, we measure the angular height of the lightning, we can hence deduce its vertical height. Thus in 1834, when there were several very elevated storms at Hulle, I found, on the 5th of June, that the lightnings were at a height varying from 1,900 to 3,100 metres, (6,233 to 10,171 feet English) on the 21st of July, the minimum of certain lightnings traversing the zenith was 1,300 metres (4,265 feet English.")

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* **Peltier** sur les Trombes; Paris 1840.

† 1130 is, however, perhaps a better rate as determined by the French Academicians.

"When storms also are not very elevated, we must admit that the clouds we see are formed after the more elevated strata, that principally constitute the storm. The rapidity with which the lower clouds are condensed give rise to a strong electric tension that is manifested by repeated discharges; this is due to the inductive action of the higher masses acting on the lower."

289. Mr. **Espy** pronounces that some clouds, which he supposes to be condensed vapour carried up by vortices, rose to the heights of ten and fourteen miles! the writer in the North American Review, No. CXXIII. April 1844, alluded to at p. 3, reduces these heights to four miles and two miles and a half.

290. Mr. **Redfield** says, (and I will not do him the injustice to attempt any abridgement) in relation to this (American Journal Science and Arts, p. 184.)

"VERTICAL HEIGHT OF THE STORM WIND.—What is the general height or thickness of the storm, and by what means can this be approximately determined? These questions and their solution are doubtless of some importance in their bearing on meteorological theories, and seem to deserve our attention.

"In nearly all great storms which are accompanied with rain, there appear two distinct classes of clouds, one of which, comprising the storm-scuds in the active portion of the gale, has already been noticed—above this, is an extended stratum of stratus cloud, which is found moving with the general or local current of the lower atmosphere which overlies the storm. It covers not only the area of rain but often extends greatly beyond this limit, over a part of the dry portion of the storm, partly in a broken or detached state. This stratus cloud is often concealed from view by the nimbus and scud clouds, in the rainy portion of the storm, but by careful observations, may be sufficiently noticed to determine the general uniformity of its specific course, and approximately, its general elevation.

"The more usual course of this extended cloud stratum, in the United States, is from some point in the horizon between S. S. W. and W. S. W. Its course and velocity do not appear influenced in any perceptible degree, by the activity or direction of the storm-wind which prevails beneath it. On the posterior, or dry side of the gale, it often disappears, before the arrival of the newly condensed cumuli and cumulo-stratus, which not unfrequently float in the colder winds on this side of the gale.

"It appears, therefore, that the proper storm-wind revolves entirely below the great stratus cloud which covers so large a portion of the storm; and we may infer also, that the production of the accompanying rain and the depressing effect of the storm's rotation on the barometer, are chiefly confined within

the same vertical limit. In regard to rain this result is in accordance with observations on the quantity which falls at different elevations above the earth's surface ; and in the case of the barometer, a like accordance is shown in the diminished range of the mercury in storms which is found in ascending from the ocean level.

" The general height of the great stratus cloud which covers a storm, in those parts of the United States which are near the Atlantic, cannot differ greatly from one mile ; and perhaps is oftener below than above this elevation. This estimate, which is founded on much observation and comparison, appears to comprise, at the least, the limit or thickness of the proper storm-wind, which constitutes the revolving gale.*

" It is not supposed, however, that this disk-like stratum of revolving wind is of equal height or thickness throughout its extent, nor that it always reaches near to the main canopy of stratus cloud. It is probably higher in the more central portions of the gale than near its borders, in the low latitudes than in the higher, and may thin out entirely at the extremes, except in those directions where it coincides with an ordinary current. Moreover, in large portions of its area there may be, and often is, more than one storm-wind overlying another and severally pertaining to contiguous storms. In the present case, we see from the observations of Professor **Snell** and Mr. **Herrick** at Amherst, Mass. ? and at Hamden, Me., (115 and 135*b* of Mr. **Redfield's** Memoir) that the true storm-wind, at those places, was superimposed on another wind ; and various facts and observations may be adduced to show that brisk winds, of great horizontal extent, are often limited, vertically, to a very thin sheet or stratum."

291. A more ready means however of placing this clearly before the mind of the plain seaman is the following—

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* See this Journal (American Journal of Science Vol. XXXI. p. 127-128.) If a disk be cut from the thin paper of Chart IV. (Mr. **Redfield's**) of a size which will represent one thousand miles in diameter, it will be found to have a thickness which represents more than a vertical mile, by the scale of the Chart. A disk of the same size, but on a scale representing a storm of but 400 miles diameter, if cut from the paper of this Journal, will also represent more than a mile of vertical thickness in the storm. These and other analogous considerations, deserve the attention of those who may think that winds are mainly induced and supported by movements or influences of a vertical character or tendency. It might be useful for those holding such views, to attempt to draw out the supposed paths of vertical induction and geographical progression in the winds, on an accurate and uniform linear and vertical scale, for the purpose of attaining a more precise standard for estimating the supposed vertical action or influence. *Note by Mr.* **Redfield** *to his paper.*

If he will take any Mercator's Chart of which the scale is one inch to a degree of longitude, and lay close down upon it the thinnest of the two Horn Cards with this book, the storm circle marked upon the card will *about** represent a Cyclone disk which reaches one mile in height, and yet is 180 miles in diameter, so that he might suppose the minutest microscopical atom or grain of dust below his Horn Card to be a ship, and if he whirled the card round he would represent the action of a rotatory storm, and its relation as to height to the surface of the ocean.

292. He will then have to bear in mind for the future, that in a Cyclone he cannot be so much said to be enveloped in a moving *column* of whirling winds, as to be caught in a thin flat disk or circle of such winds; which may be from 100 to 1000 miles in diameter, but only from one to three or four miles, or perhaps at most five miles high; and that from such an elevation as the Peak of Teneriffe or Mouna Roa, he might perhaps look down upon a stratum of storm-clouds, beneath which his ship was cutting away her masts or foundering in a hurricane: just as travellers in the Alps have looked down upon thunder storms which were devastating the corn fields and vineyards of the vallies below. In the section on banks of clouds, we shall shew that hurricanes (Cyclones) *have* been, pretty nearly, so seen from elevations!

293. To assist the reader further in forming a correct idea of what a disk of storm, of moderate extent and height is, I have also traced below the framing line of the Barometrical Chart, dotted lines representing the disks of Cyclones of 300 miles in diameter, and of ten, seven and three miles in height, with a supposed vortex *v.* at the centre

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* *About.* We do not require exact accuracy in these things; but the calculation is in round numbers: that on a scale of one inch the 360° would require a globe of 360 inches in circumference, or 120 inches in diameter, and 8,000 miles (diameter of the earth): 120 inches:: 1 mile: to .015 inches. Now 100 average horns measure about 1.5 inches in thickness when close together, so that each averages about .015.

which has a calm of ten miles at its base. He may from this estimate what it would be if five or even fifteen miles high, and how fallacious all our notions are apt to become when we consider these storms as whirling *columns*, and insensibly go on to liken them to water spouts as to height, which it is evident they cannot at all resemble, since their size (diameter) may be said to have been in many cases estimated to a few miles with tolerable correctness; and in frequent instances the next stratum of clouds above the storm, either at rest or moving altogether differently, has also been clearly distinguished and noted: so that we may boldly affirm that at most the height (thickness is the more correct word) of the disk does not ever exceed ten miles, and usually falls far short of it. **Mr. Redfield**, as just quoted, thinks it oftener below than above *one* mile.

294. Indeed, I am inclined to believe that the storm-disk is somtimes so *thin*, that at, or near the centre, whether calm or not, it has often been *seen through*; and the following I take to be instances in which this has occurred.

In my Eighth Memoir (Journal Asiatic Society, Vol. XII.) Dr. **Malcolmson**, Surgeon Political Residency, Aden, in giving an account of a Cyclone in the Arabian Sea, in which the ship *Seaton* of Bombay was dismasted and in great danger, says—

"During the height of the storm the rain fell in torrents, the lightning "darted in awful vividness from the intensely dark masses of clouds that "pressed down, as it were, on the troubled sea." *In the zenith there was visibly an obscure circle of imperfect light of ten or twelve degrees.*

In the whirlwind of the *Paquetbot des Mers du Sud* forming the second part of my Fifth Memoir (Journal Asiatic Society, Vol. XI.) which was a true Cyclone by its veering, and a tornado as to duration and violence, is the following passage—

"A very remarkable fact is, that while all around the horizon was a thick "dark bank of clouds, the sky above was so perfectly clear that the stars

" were seen, and one star shone with such peculiar brilliancy above the head " of the foremast that it was remarked by every one on board."*

The ship *Tigris*, Captain **Robinson**, experienced a short but severe tornado-Cyclone in April 1840 in Lat. 37° to 38° South, Long. 68° to 75° East, track *e.e.* on Chart No. II., and in the midst of it while lying to, "the clouds broke away and the sun shone out, the whole surface of the water as white as snow with foam and coloured like the rainbow in all directions. At 11 the wind blew with such fury that the three top-gallant masts were blown away, the spencer split to pieces, and the furled sails blown in shreds from the yards." We have no express note here, it is true, of the surrounding bank of clouds, but no doubt there was one, for the ship had still to lay to for three or four hours under bare poles.

Col. **Reid** states, p. 529, that—

" During a gale in the North Atlantic, about Lat. 40°, in a ship hove to, after the clouds broke sufficiently to see through the lower ones, the upper light clouds appeared in a quiescent state, as if the storm was confined to an altitude little above the surface of the globe."

We have many instances on record, indeed, in which, at the onset or towards the close of storms, the upper clouds have been seen moving from 8 to 16 points differently from those in the storm below, and the weather above appeared altogether fine! And the whole tendency of this is to shew, that not only a Cyclone has no resemblance to a column, but that it may be at the centre and towards its edges, nothing more than a very thin disk!

295. **Banks of Clouds.** These are at times very remarkable on the passage, or approach of, and during Cyclones; and there is no doubt that the clouds and other celestial objects, carefully watched,

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* We are forcibly reminded here, and there may be more than a mere poetical figure in it, of the beautiful invocation to the Virgin by the Mediterranean mariners—

" In mare irato, in subita procella,
Invoco te MARIA *nostra benigna stella.*"

" In raging seas and in the tempest's war,
We hail thee, MARY! as our guardian star."

may often afford the vigilant seaman far more advice and warning than is usually supposed. We are perhaps too much accustomed to rely on our instruments now-a-days, and we neglect these signs, which must, after all, have been the barometers and simpiesometers of **Drake, Cavendish, Dampier,** and all our daring band of Naval and Commercial Navigators up to the end of the last century, and still are so of our hardy fishermen and coasters. Some of these signs may at least serve as corroborative indications, and the careful observation of them, (to which indeed I am desirous of directing attention) lead to farther and perhaps useful knowledge.

296. It seems certain that Cyclones have been frequently *seen* as forming thick banks or walls of cloud, at a greater or less distance from ships which have escaped from, or have afterwards been caught in, or by the common and too frequent error have *sailed into* them. The following are instances.

Colonel **Reid,** p. 47, 2nd Ed. gives a letter from Mr. **Mondel,** Master of the *Castries,* West Indiaman, who saw a bank of clouds so thick and close, that in broad daylight at 3-30 P. M. it was taken for land by all on board, though at the time the ship was 350 miles from St. Lucia, at which island a severe Cyclone was felt on the following day.

Dr. **Peyssonnel,** (Phil. Trans. for 1756, p. 629) says that being upon Grande Terre, and viewing thence the whole island of Guadaloupe during a Cyclone,

"I observed that the storm, which had affected us in the night, was now very violent upon the Island of Guadaloupe: it was a frightful, thick, black cloud, and seemed on fire,* and gravitating towards the earth: it occupied a space of about five or six leagues in front, and above it the air was almost clear, there appearing only a kind of mist."

The distance from the centre of Grande Terre to the centre of Guadaloupe is about 20 miles. We cannot judge what the horizontal or vertical angles were from what is here said, but the description remarkably accords with the following from Balasore and Point Palmiras.

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* From flashes of lightning I presume is meant? or the effect of the sun's rays?

"At Balasore, Mr. **Bond,** Master Attendant, informs me that the gale of June 1839, see First Memoir, Journal Asiatic Society, Vol. VIII. was foretold by the blackness of the heavens to the Eastward."

"In the *Duke of York's* hurricane in 1833, though it did not reach to Balasore, 75 miles to the S.S.W. of Kedgeree where that vessel was lost, the bank to the Eastward in the heavens so plainly indicated a gale that every person barred up their doors and nailed them. We had only a good top-gallant breeze."

"Mr. **Richardson,** Branch Pilot in the H. C. Service, also informed me that during this hurricane while he was driving about with all his anchors down, some passengers whom he had previously landed at the Black Pagoda, were upon the top of it, and felt no excessively violent wind, though they *saw* the horizon very black, and the sea dreadfully agitated to the N.W."

From the Black Pagoda to Kedgeree, and the centre of the Cyclone was to the South of that place, the course and distance is about 135 miles, and I have placed the line of the track of this Cyclone (*j*. on our Chart No. III.) 130 miles to the N.E. of the Black Pagoda.

In the China Sea, the brig *Virginie,* which narrowly escaped running into a tyfoon by being on that quadrant of it where the wind was foul for her, states in her log, abridged in my VIth Memoir on the storms of that sea, that they "saw a heavy bank of clouds to the E.S.E." Mariners so often see this appearance of a bank of clouds, that when they mention it we must take it to be of a remarkably threatening kind. I have many such instances on record where there is no doubt, to my mind at least, that ships have seen the bank of clouds forming the outer verges of storms; much resembling, as we may suppose, those which surround the upper extremity of a water-spout.

297. The cases also in which ships have seen remarkable banks or walls of cloud surrounding them wholly or in part, or as just quoted at p. 220 where the clouds have been so dispersed in the zenith during the utmost fury of the Cyclones, as to allow the clear sky or stars to be seen overhead, are by no means uncommon. Colonel **Reid** gives, p. 116, the log of the *Duke of Manchester,* which ship in a Cyclone in 32° North, 77° West, in the month of August, saw—

"A most extraordinary phœnomenon present itself to windward, almost in an instant resembling a solid black perpendicular wall, about fifteen or twenty degrees above the horizon, and disappeared almost in a moment; then in the same time made its appearance, and in five seconds was broken, and

as far as the eye could see: from this time to midnight, blowing a most violent hurricane with a most awful cross sea breaking constantly on board fore and aft."

I have already alluded, p. 226, to the whirlwind of the *Paquetbot des Mers du Sud*, which is certainly an instance of the bank of clouds surrounding a vessel in a Cyclone.

Captain **Miller**, of the *Lady Clifford*, whose good management I have adverted to at p. 123, observes as the Cyclone was approaching, and before it was travelling past to the N.E. of him, and while his barometer had as yet fallen but very little, being at 30.05 at noon, and at 29.91 at midnight, that—

"Towards evening a thick cloud or bank gathered in the N.E. and a long swell set in from that quarter.* At 10 P. M. the whole sky was overcast and the barometer began to fall."

I have quoted at length at pp. 108, 109, the capital instance of the *Earl of Hardwicke*, Captain **Weller**, who undoubtedly saw the body of the Cyclone which he avoided, in the bank or arch of clouds to the North and N.W. which he describes.

In the Nautical Magazine for January 1847, is an excellent account of a tyfoon-Cyclone in the China sea in September 1842, by Captain **Hall** of the *Black Nymph*, who also saw distinctly the body of the storm approaching. He says—

"Towards evening I observed a bank in the S.E., night closed in and water continuing smooth, but the sky looked wildish, the scud coming from N.E., the wind about North. I was much interested in watching for the commencement of the gale which I now felt sure was coming, considering that Colonel **Reid's** theory being correct, it would point out my position with respect to its centre. That bank in the S.E. must have been the meteor approaching, and the N.E. scud the outer N.W. portion of it, and when at midnight a strong gale came on about North to N.N.W., I felt certain we were then on its Western and Southerly verge."

In the letter of the Commander of the *Judith* and *Esther* to Colonel **Reid**, p. 75 of his work, it is stated at the conclusion of the hurricane (Cyclone),

"At 6 P. M. the gale abated and the sea fell fast, the appearance of the sky at this time was very remarkable, being of a deep red colour to the North, and looking very dark to the West as if the gale was moving in that direction."

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* See p. 156 for what is said there of distant swells.

The same kind of appearance after a severe Cyclone in the Arabian sea, is noted by Dr. **Malcolmson** in his account of the *Seaton's* disasters, quoted at p. 220.

Colonel **Reid**, p. 27, speaking of the Barbadoes hurricane of 1831, which also devastated St. Vincent, says—

"A gentleman of the name of **Simons**, who had resided for forty years in St. Vincent, had ridden out at day-light, and was about a mile from his house, when he observed a cloud to the North of him so threatening in its appearance, that he had never seen any thing so alarming during his long residence in the tropics: he described it as appearing of an olive-green colour. In expectation of terrific weather, he hastened home to nail up his doors and windows, and to this precaution attributed the safety of his house."

Colonel **Reid** quotes also the log of the *Rawlins*, in which, after a Cyclone, is noted, "A dismal appearance to the N.W.," and Mr. **Redfield**, Dr. **Mitchell** of New York, as stating that the labouring people in New York had learned to prognosticate from what quarter the wind would set in, in their storms, by noting where "the haze or *cirrus* which appearing at sunset indicates its approach," first appeared.

298. **Signs of approaching Cyclones.** I have remarked in the section on the banks of clouds, that it may be well worth the careful seaman's while to observe watchfully the atmospheric and other signs which were the barometers of our forefathers. As there are many dispersed notices of these indications, and these would require much detail to explain them, I have thought that, both to save space and to enable the mariner to refer to them at a glance, the form of the following table would be the shortest and best in which to set them out for our purpose. I have followed it by a few remarks on some of the phœnomena, celestial and terrestial. It is not intended by any thing that may be said, or cited from others, that the seaman should consider any one of these signs as *certain* prognostics of a coming Cyclone, but he will allow readily that in certain seas and at certain seasons of the year, his attention *and that of his officers* cannot be kept too much awake; and any one or more of our signs may, by inducing a closer look-out on the barometer and simpiesometer, give him from an hour to six hours more TIME for his precautions, whether at sea or in harbour: Of time no class of men should better know the value than sailors.

Tabular view of the Celestial and Atmospheric Signs stated by various

Authority.	Place of Observations.	Sun.	Moon.
1. Capt. **Langford,** Phil. Trans. 1698, p. 407; from the Caribs, ...	West Indies, ...	More red, ...	Occur at full change or quarters, ..
		Often with a burr about it, ...	A great burr about Sun.
2. Dr. **Peyssonnel,** Phil. Trans. 1756, Part 2,	West Indies, ...	Setting sun blood-red, ...	.....
3. Dr. **Morrison,** Chinese Repository, Sept. 1839, p. 230, ... **C. B. Greenlaw,** Esq., **Horsburgh,** various logs. **M. La Place, Dampier,**	China Sea and Coasts of Hainam, ...	Capt. **Misbet,** of the H. C. S. *Essex*, had observed in five Tyfoons in the China Sea and one on the Malabar Coast the sun to set of an excessive fiery red colour, ...	.....
4. *Derrotero de las Antillas*, as translated in **Purdy's** Atlantic Memoir, and Lt. **Evans,** R. N., ...	Coasts of Mexico for the *Nortes*, ...	.....	.....
5. Mr. **Gittens** of Barbadoes, quoted by Col. **Reid,** p. 36, and Bermuda Gazette, ...	West Indies, Barbadoes, ...	Of a blue appearance; the same where shining in a room. Appearance of the sun at day like that of full moon.	.....
6. Capt. **Rundle** quoted by me XI. Memoir J. A. S. Vol. XIV. Capt. **Jenkins** H. C. S. *City of London*, MSS. from E. I. C.,	Southern Indian Ocean, ...	.....	.....

Authors to indicate the approaches of Tyfoons, Hurricanes, &c.

Stars.	Clouds.	Atmosphere.	Notes.
Look big with burrs about them, ...	N. W. Sky very black and foul, ...	A great calm, sometimes for an hour or two strong Westerly wind,	These Signs often at change or quarter of Moon, if a Hurricane is to be expected at full.
.....	Little clouds, moving with great rapidity,	Calms and frequent shiftings of breezes from all points.	
.....	Fiery in thick masses, frequent rainbows broken,* ..... Irregular masses moving against or across the usual monsoon,†	Slight noises heard at intervals a few days before, wheeling round and stopping quick, and also thick muddy atmosphere,* ..... Remarkable clear weather, distant land very distinct,†	* The descriptions of Chinese fishermen, and possibly an imperfect translation. † European accounts.
.....	Lightning on the N.W. and N.E. horizon; at sunset Cumuli, changing to dark nimbus of a deep purple, ...	Thick fog or low scud flying fast to the south, or (**Evans**) extraordinary white haze or mist distinct from common fog, principally to the North, ...	Weather warm, hot, and oppressive sometimes affecting the breathing.
.....	Darting forward in divided portions and with a fleet irregular motion, not borne by the wind but driven as it were before it, ...	Distant roar of the elements, as of winds rushing through a hollow vault.	
		White objects of a decided light blue colour.	
Capt. **Rundle**, dancing, sickly appearance, ...	A remarkable kind of lightning, shooting up in stalks or columns in the horizon, or with a dull glare, and remaining for a short time, ...	Capt. **Rundle, H. P.**, and Cyclone storm at Baticolo; a moaning noise rising and falling with the wind.	

Authority.	Place of Observations.	Sun.	Moon.
7. Capt. **Stewart** *Rajasthan*; XIV. Memoir J. A. S. Vol. XIV. and other logs and accounts,.....	Arabian Sea, ...	.....	.....
8. Popular and well known at the Mauritius; **Thom** p. 92, *Exmouth's* log; Newspaper acct. of *Northumberland's* Cyclone; Captain **Biden** and others, ...	Southern Indian Ocean and Mauritius, ...	.....	.....
9. **Piddington,** Various Memoirs, Brig *Freak*, Captain **Smoult,**	Bay of Bengal,...	.....	.....
10. **Lynn,** Star Tables H. C. S. *Buccleugh's* Tyfoons,	Northern Pacific Ocean, ...	.....	.....

Stars.	Clouds.	Atmosphere.	Notes.
.....	Light clouds moving with great rapidity in different directions. Thin low damp vapours flying rapidly across the upper clouds.		
.....	Remarkable red colour of the clouds and all objects appearing tinged with red colours: described as lurid red to bright *crimson* and brick-dust haze,.....	.....	This is well known and considered as an almost infallible sign at the Mauritius and Bourbon. With the ship *Manchester* in 22° S. 86° East, it also occurred during the height of the Cyclone.
.....	Rising rapidly appearing ragged and black with white feathering edges and stretching out with long tails towards the Zenith. Thick banks over the place of the Cyclone growing longer and darker.		
.....	Dense clouds surrounding the horizon to 10° or 15° in height; upper edge tinged with red, and red light reflected from them on all objects.		

Tabular view of the Terrestial and Oceanic signs stated by various Authors to indicate the approach of Cyclones.

Authority.	Place of Observation.	The Sea.	Sea Shore.	Land Generally.	Notes.
1. Capt. **Langford**, &c.	West Indies, ...	Smells stronger than at other times, ...	.....	Hills clear of clouds and fogs. Noises in caverns or wells like a storm.	
2. Dr. **Peyssonnel**, ...	West Indies,.....	.....	Sea birds come to land.		
3. Dr. **Morrison**, Chinese fishermen, &c.	China Sea, ...	Gives a bellowing sound and boils up, dashing loose rocks against each other. Sea weeds plentiful, ...	Water fowl fly about.		
4. Col. **Reid**,.....	Bermuda, ...	Sea assumes a muddy or brown colour,.....	Swell rolls in though hurricane is at 600 miles distance.		
5. **Ulloa**,.....	Western Coast S. America, Coast of Peru and Chili, ...	Birds called by the Spaniards Quebrantohuessos (probably the *Falco ossifragus*) are seen to appear in great numbers on the shore and ships.			
6. *Derrotero de las Antillas* as translated in **Purdy's** Atlantic Memoir,	Coast of Mexico, for the *Nortes*, ...	Sparkles, ...	.....	Moisture on walls and pavements. Mountains clearly defined some with thick clouds like a sheet.	
7. Mr. **Gittens**, of Barbadoes, quoted by Col. **Reid**, p. 36, and Bermuda Gazette, ...	West Indies, Barbadoes, ...	.....	.....	The motion of the branches of trees not bent forward as by a stream of air, but constantly whirled about.	

Remarks on the foregoing tables of signs.

299. **Red Sun, Sky, and Light.**—In this table we find the redness of the sun is a commonly known sign from the Mauritius to China and the Pacific. It is also noted by **Virgil** for the coasts of Italy.* We shall examine this with the remarkable red colour of the clouds and of all objects, which is so well known at the Mauritius as a precursor of the Cyclones there.†

It is very certain that this phœnomenon of red sky, red clouds, and red light does occur as described, and moreover that it must therefore occur under unusual circumstances; for were the conditions which occasion it usual ones, it would frequently be seen, and be no sign at all. It is its rarity, its appearing only at one season, and generally, we may suppose, closely preceding the Cyclones, which has caused it to be specially noted as a sign.

It is very difficult to give the plain seaman an idea of the causes which may produce this apparent excess of the red rays of light over the others; and indeed meteorologists would not altogether agree in their views were they to undertake the explanation, not only of the appearance itself, but of why it should be seen at particular times; and it is not the object of this work to explain *causes*, but rather to deal simply with effects, and to point out here and there the researches which may lead us to the discovery of causes. Hence we shall only briefly say, that *probably* the red colour of the sun and sky on this occasion is due to the absorption of the greater part of the blue rays of the sun's light,‡ which thus will leave only the red, and yellow rays to form red, orange, and yellow lights of various shades and intensities, the greens and violets being so faint from the want of blue as to lose all power of acting their part in producing pure white light.

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* I. Georg : v. 453.

† On a recent occasion it occurred in Calcutta; and the general remark amongst every person who knew the Mauritius, and with Creoles of the island residing in Calcutta, was immediately, that a hurricane would have been expected at that island.

‡ Every seaman I hope knows that the pure *white* light of the sun is a compound of the seven prismatic colours which are themselves compounded from the red, yellow, and blue rays.

300. How this absorption and refraction of the rays (for both probably occur) takes place, we cannot readily say. We know by the experiments of **Hassenfratz** and others, that the light of the sun passing through dense strata of the atmosphere, or as at sunset, through a much greater extent of it, loses a large proportion of its blue rays, and we may suppose *theoretically*, when the redness occurs at noon-day, that not only the light has to force its way through a dense atmosphere; but, also through clouds of at least three different kinds, the common fog-clouds, the invisible clouds, (see p. 216) and perhaps snow clouds.*

The attentive mariner, then, will be satisfied to know that this red light *must* be produced, like the Cyclone of which it is in certain parts of the globe the warning sign, by some peculiar state of the atmosphere, in which causes are at work that he is ignorant of, but which will produce effects against which he must be on his guard; and that it is not a mere chance occurrence which has been superstitiously made a *sign* of by the ignorant. One of its peculiarities also is, that this red light does not appear to be usually known in India. I have not at least met with any mention of it as the precursory sign of a Cyclone. The blue light mentioned by Col. **Reid**, p. 36, as having occurred at Barbadoes and Bermuda is very remarkable.

301. For such of my readers as may not have seen, and may therefore be desirous of having some description of this red appearance, I insert the following:

Mr. **Barnett**, passenger in the ship *Exmouth*, in the Cyclone of May 1840, of which the log is printed by Mr. **Thom**, Tracks on Chart II. says in a letter printed in the Calcutta *Englishman*, which very graphically and minutely describes their distress—

"On the morning of the 30th, we witnessed a most extraordinary phœnomenon; the day appeared to break full an hour before its time, though there

* Clouds which are well known to æronants and to travellers in high mountains, and are in fact the frozen fog-cloud. Then each of these clouds may be, and probably are, differently electrified, which again may vary their properties of reflecting or refracting the light which reaches the earth. The fact that even different strata of air (invisible clouds?) are in opposite states of electricity during a calm, has been distinctly shown by MM. **Peltier** and **Becquerel**. See *Peltier sur les Trombes*. Introduction p. VII. to IX.

was no apparent break in the heavens from which it could be said light broke; all was seen through the medium of bright crimson. Sails, men, sea, and even grey clouds, appeared as acted on by a Claude Lorraine glass; it gradually decreased till sun rose.* The 1st of May was one of the most lovely days I ever remember to have witnessed, and on it and the 2d, we made the first two fair runs we had had, but the sea continued still unaccountably high, and was running against the wind."

The *Exmouth* was dismasted on the night of the 3d and morning of the 4th. Capt. **Biden** in the log of the *Princess Charlotte of Wales*, Track *k*. on Chart No. II. says—

"At sunset on the 26th, though dark and cloudy, the sea was completely tinged with a red colour."

In a newspaper account of the *Northumberland's*, Cyclone, Track *q*. on Chart No. II.,

"The approaching storm was indicated in the morning of the 6th by a fall in the barometer of one-half *inch* (?) and a peculiar brick-dust, hazy appearance."

In the Northern Pacific, in the H. C. S. *Buccleugh's* Log, Tracks *a*, *b*, *c*, on Chart No. IV. Mr. **Lynn** says—

"At sunset the clouds predicted another severe typhoon. This appearance was that of remarkably dense and large clouds surrounding the horizon at an altitude of about 10° or 15°, having thin edges tinged with a deep crimson border, as if bound with a ribbon of that colour, and reflecting an awful redness upon the sails, *which appearance had also preceded the former gale.*"

302. In **Dampier's** description of a China sea Tyfoon, in the second chapter of his Voyage to Acheen and Tonquin, many of these signs, and particularly the red bank of clouds as above described by Mr. **Lynn**, and our banks of clouds of the preceding section,† may be recognised. He says—

"The typhoons are a sort of violent whirlwinds which reign on the coast of Tonkin in the months of July, August and September; they happen generally when the moon changes or becomes full, and are almost always preceded by

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* Mr. **Thom**, p. 92, gives the Log, which says that the appearance lasted for five minutes.

† In this and other quotations from **Dampier**, I am either quoting at second-hand or translating, (mostly from the French), having been unable to procure the work in Calcutta! The Italics are mine.

fine, clear and serene weather, accompanied by light and moderate winds. These light breezes vary from the usual wind of this time of the year, which is more from the S.W. and become North and N.E.

"*Before these whirlwinds come on there appears a heavy cloud to the N.E. which is very black near the horizon, but towards the upper part it is of a deep dull reddish colour, higher up it is more brilliant,* and then to its extremity it is pale and of a whitish colour which dazzles the eyes. This cloud is frightful and alarming, *it is sometimes seen twelve hours before the whirlwind comes.*[*] When it begins to move with rapidity you may be sure that the wind will blow fresh. It comes on with violence, and blows for twelve hours more or less from the N.E. It is also accompanied with terrible claps of thunder with sharp and frequent lightning, and rain of excessive violence. When the wind begins to abate the rain ceases all at once and a calm succeeds. This lasts thus an hour more or less, then the wind coming from about S.W., blows with as much violence from that quarter, and as long as it has blown from the N.E."

303. In the West Indies and Atlantic, we do not find this appearance of a red sky and red light sufficiently marked to assume it as a frequent, if not almost a constant sign of an approaching Cyclone. At pp. 75 and 88 of Colonel **Reid's** work, we find it casually noticed only, but not in such connection as to authorise us to call it a premonitory sign there.

With respect to the instances we have cited, we should also remark that this light must sometimes have been *reflected* and at others transmitted, and therefore *refracted* light. It is to be hoped that future observers will not omit to notice this phœnomenon more in detail, so as to inform us of the state of the whole sky at the time, position of the sun, and every other particular.

304. CLOUDS. Amongst the cloud signs, light divided portions of them carried rapidly on with irregular motions, seem to be one of the commonest signs, after the banks of clouds and red light of which we have just treated in detail.

305. LIGHTNING. I have noted in a preceding page the peculiar kind of Aurora Borealis-like lightning noticed by Capt. **Rundle**, and the following is his remark at length with my note upon it, XI. Memoir, Journal Asiatic Society, Vol. XIV.

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[*] This is exactly a bank of coloured clouds indicating a Cyclone coming down from the N.E. or E.N.E. like many of our tracks thereabouts.

"I observed those modifications of lightning more like the Aurora Borealis, which I have seen in the North sea, or rather more like the Aurora Australis, which I have seen off Van Dieman's Land and New Zealand. I have never seen it in low latitudes, but as a precursor of strong weather. It gradually lightens up the Western horizon with a sudden dark red glare, and thus flickers about for a few seconds and gradually disappears."

"Again visible to the W.S. Westward, the sullen red glare and flickering lightning; midnight squally, sea presenting flashes of phosphoric light in all directions.

"*My note is as follows:*

"I have found while correcting this page for the press, a single instance in which this remarkable kind of lightning is described. It occurs in one of the replies to a circular addressed, at my suggestion, by the Hon'ble the Court of Directors, E. I. C. to their retired officers, requesting information on storms in the Indian Ocean and China Seas, by Capt. **Jenkins**, then commanding the H. C. ship *City of London:* who says, speaking of an approaching hurricane in March 1816, in Lat. 12° to 18° South, Long. 78° to 76° East, for which, warned by his barometer, he was preparing: "At 7, the appearance of the atmosphere altered, constant vivid lightning resembling in the distance the Northern lights, with frequent hard gusts of wind," &c. We are not to suppose from its being so unfrequently noticed that it is therefore of unusual occurrence; seamen are so accustomed to lightning that they rarely take the trouble to describe it."

The following note is by Capt. **Stewart**, of the ship *Rajasthan*, printed in my Fourteenth Memoir. It refers to the approach of a small but severe Cyclone, experienced by him in the Arabian sea—

"On the evening of the 4th December,* I observed a remarkable kind of lightning to the North Westward, shooting up perpendicularly from the horizon in stalks or columns of two and three at short distances, it was not at all bright, but rather of a dullish glare."

306. If we consider that the bank of clouds seen at the approach of a Cyclone, is the edge or side of a disk, such as that shewn in our Barometrical Chart p. 193, and admit that extensive electric action is going on towards the centre, while the outer part is a dense ring of cloud, we shall understand how this Aurora Borealis-kind of lightning

* His Cyclone occurred on the 5th, and was then travelling up to him from the S.E., *if it was formed* (of which we have no evidence), but there *was* another, and this is very remarkable, raging to the N.N.W. of him at this time with the ship *Monarch*, at about 2° of distance.

may be the reflection of a series of continued discharges seen above the wall of clouds, just as we see the distant red sky of a fire behind masses of houses or trees, or the reflected flashes of the discharges of a volcano behind a range of mountains. Continuous electric discharges (such as by the way, no European electrician has even dreamed of), are by no means uncommon in tropical climates, and especially amongst the Eastern islands. In the Java sea, off the South coast of Borneo, it is no exaggeration to say that the lightning sometimes *pours* down in cascades or columns from the clouds, and this in four or five places at once! and in Madras roads the discharges of sheet lightning behind, or rather above, thin transparent stratiform and cirrhous clouds, covering the whole sky, are sometimes so incessant for hours together that small print may be read by them; they resemble, in fact, the corruscations of the glow-worm! Sir **M. Faraday**, I observe in a recent paper, but to which I cannot now refer, notices a "distant illumination of the clouds," which he thinks, if I recollect rightly, is simply a reflection of distant lightning, but no European lightning can give any idea of the terrific magnificence of that of the Eastern Archipelago and Eastern Seas in general.

307. **Seasons at which Hurricanes (Cyclones) occur.** I have placed here what we *as yet* know of the times at which Cyclones have been known to occur in various parts of the world, from which the mariner may deduce, *with some general probability*, the chances of one on his voyage. On this our information at present is very imperfect (except perhaps for the West Indies), but nevertheless it may be found useful now and then to look at the following table, in which the number of Cyclones are marked for the years of which we have any record. The use of it will be seen at once to be, that in running the eye along the line, of the West Indies for example, we see that in certain months more or fewer Cyclones occur; and in some none at all are recorded during the long period of years shewn by the first column. It is by no means to be supposed that we have any accurate registry of these meteors for any part of the world, but the numbers given *may* approach nearer to correctness than we should at first imagine, because if a Cyclone was to occur out of the usual months or seasons it would be much remarked.

The seaman also should not fail to keep in mind, what I have said of the difference between Monsoon Gales and Cyclones; and that his monsoon or trade may rise to the strength of a very strong gale, but it will still be steady, and his barometer without depression.

308. *Table of the average number of Cyclones in different months of the year.*

For what number of years ascertained.	Locality.	Authority.	Months.											
			Jany.	Feby.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.
123	West Indies, ...	Naut. Magazine, ...	...	...	...	...	...	1	2	13	10	7	...	...
59	.....	U. S. Journal 1843, page 3, ...	...	...	..	..	...	1	5	13	13	9	...	...
39	Southern Indian, Ocean,	**Reid, Thom, H. Piddington,**	9	13	10	8	4	...	...	...	1	1	4	3
46	Bay of Bengal,	**H. P.,**	1	...	1	1	7	3	...	1	...	7	6	3
64	China Sea,	**H. P.,**	...	...	...	..	...	2	5	5	18	10	6	...

309. **Whirlwinds and Waterspouts.** There seems, as far at least as effects are concerned, so complete a gradation from the trifling and harmless dust whirlwind to the larger and mischievous ones of the same kind on shore, *all of which become water-spouts when they reach or cross water,** to the mischievous fine weather whirlwinds which have dismasted ships at sea, and from these again up to the great water-spouts and the smaller tornados or tornado-Cyclones, that a book on Storms would be incomplete that did not

* Of which we shall give instances.

advert to them. I shall perhaps do so at some length, but I desire to say here, that I do it without specially advocating any particular theory, but rather desirous of indicating from various facts what appears highly worth inquiring into.

310. The seaman cannot be too often told that a theory, whether directly proposed or hinted at by a writer, or framed almost unconciously by himself, is not a *rule*, but a torch to assist in guiding us, and to be exchanged for another as soon as we find a better one; and that it often occurs, that by the very destruction of the wrong theory by well observed facts, we get hold of the right one. I proceed first to describe these phœnomena by my own knowledge, or by extracts in the order in which I have named them.

311. The simplest forms of whirlwinds are such as are not unfrequently seen in Europe, but in tropical climates they are far more frequent, and indeed in some countries and districts, during the dry season they occur daily, and often in numbers. On the plains of India they are seen most frequently in the mornings, when one or more slender whirling columns of dust leaves, &c., are suddenly seen to rise and to move about, at first slowly, and then to start off as it were on some line of direction, whirling light bodies about as they pass them, and when they meet with obstacles, as trees, houses, or the like, sometimes passing over them, and at others being broken up and lost amongst them. In open spaces they become fainter and disappear.

312. No perceptible change of temperature accompanies these little whirlwinds, and I am not aware that any electric experiments have been performed on them. They appear in India, by the evidence of a friend, Mr. **J. Bridgman** of the Goruckpore district, to turn indifferently either to the right or left, i. e. either ↻ or ↺. This gentleman has at my request taken the trouble to observe several, with a view to ascertain in what direction they rotated, and he says—

"I forgot to communicate to you my observations on the petty whirlwinds which occur in the cold weather, and about which we had talked two years previously, as possibly having a similar origin to the greater ones which constitute storms and hurricanes. I watched for them with care, but it was a long time during that season 1839-40, before any of the phœnomena in question

occurred. There were many whirlwinds, but always in a strong breeze of which I considered them mere eddies. They turned indifferently N.E. S.W. and N.W. S.E., but generally the former. At length one occurred which was to the purpose; the day was cloudless and the air stagnant or nearly so. It turned the right way (for the theory) i. e., N.W. S.E., and moved forward at the rate of five miles or so per hour, from N.E. to S.W. I saw no more that season, but the following cold weather 1840-41, I saw a great number of the kind to be observed upon, viz., those occurring suddenly while the surrounding atmosphere is stagnant and undisturbed. The first three or four were conformable to the theory, and turned N.W. S.E., the next few turned the reverse way, the remainder turned indiscriminately, some one way and some the other, and I became convinced that they depended upon no rule, or at least no rule producing uniformity of motion."

313. In the Journal of the Asiatic Society, Vol. IV. p. 714, Mr. **J. Stephenson** gives several notes on the sand columns which he frequently observed on the sand banks in the bed of the Ganges. He describes them varying from 20 to 100 feet high, and the large ones about twelve feet in diameter, having a whirling motion and remaining perfect several minutes. The natives affirm that persons are sometimes killed or hurt by them. The same account is given of them in the snowy steppes of the Himalaya mountains in **Moorcroft's** travels, as follows:

"I had never seen the phœnomena of the whirlwind more common than on this plain: It was, perhaps like that of the Arabian desert on a smaller scale, raising a column of sand suddenly to a great height at one particular spot whilst all around the air was perfectly calm. In general, these gusts are not at all dangerous, but strange stories are told of their occasional violence in particular spots, and they are said to be sufficiently strong at Digar, to carry horses and men off their feet, being accompanied by reports like those of artillery. I can confirm the truth of these last stories to a less exaggerated extent, having heard on the Digar Pass the wind howling through the crags at a very considerable distance, with a noise occasionally like that of a falling stone. Possibly an exposed portion of rock had been blown down."

314. In **Rich's** "Babylon and Persepolis," they are thus described, p. 228—

"Those kind of *sand-spouts* or whirlwinds which are called in India "Devils," are very common in the plain of Shirauz, and often present a very curious appearance, when ten or twelve of them may be seen at once in different places, rising into the air like huge columns. They are generally seen com-

mencing by rising out of the earth with violence like a burst of smoke from a volcano, and gradually extending themselves upwards. The people here say that they are not formed at night, or in the early morning or evening."

315. Col. **Reid** gives at length the description of the great moving pillars of sand in the Nubian desert as seen by **Bruce**, who at one time counted eleven of them together, and describes them as being 200 feet high though only 10 feet in diameter; and we know, from history and travellers, the undoubted fact that, in the deserts of Africa, armies and caravans have been overwhelmed and destroyed by them from the days of **Cambyses** to the present time. Colonel **Reid** also quotes Captain **Lyons**, describing those of Mexico, which exactly agree with what we have said of them, as they occur in India, only that Captain **Lyons** estimates his as from 200 to 300 feet in height. Lieutenant **Fyers** describing those of Western India, estimates them at about 18 feet in diameter, and "some hundred" in altitude.

316. The mischievous kinds of these land whirlwinds seem to be nothing more than those just described, but of force enough to destroy houses and men, uproot trees and even to tear, break and throw buildings down, and they may be traced, in accounts from various parts of the world as well as in India, of all sizes; from a few feet up to some hundred yards in diameter, and as occurring in all kinds of weather, and by night as well as by day. Many of these also in passing brooks or ponds, have been known to assume the appearance of water-spouts for the time, and to raise up the water and fish with it. **Horsburgh** (Introduction p. 9,) once observed all these phœnomena together in a whirlwind. He says—

"I have observed one pass over Canton river, in which the water ascended like a water-spout at sea, and some of the ships that were moored near its path, were suddenly turned round by its influence. After passing over the river, it was observed to strip many trees of their leaves, which, with the light covering of some of the houses and sheds, it carried up a considerable way into the atmosphere."

317. We come next to the singular class of fine-weather whirlwinds, or those which appear in comparatively fine weather at sea, which suddenly and seriously damage or dismast ships, committing, like those on shore, all sorts of mischief, from carrying away studding-

sail booms and royal masts, to downright dismasting; these seem from the accounts which I have met with in print, to occur mostly (or always?) in the day-time, and indeed their whirlwind character is not so well distinguished at night. Most seamen have met with the lighter sorts, but the more serious ones are fortunately not common, and indeed we are not certain, from any of the published accounts, that they *are* whirlwinds forming miniature Cyclones, as they are usually confounded with the white squalls, so well known to seamen, and which rather appear to be straight-lined winds of excessive violence, but which are seen approaching, and in fact named from their whitening the horizon with foam like a mass of breakers, or from appearing at first like a white cloud.

318. Colonel **Reid** quotes the instance of the ship *Sir Edward Paget*, which lost her fore and main masts in a sudden *squall* shortly after leaving Madras roads; but the newspaper accounts, to which I have referred, are very incomplete, stating that it was a sudden squall only, and that reports were current that both masts were rotten, &c., so that it is impossible to say what were the circumstances.

I am indebted to a friend for a very remarkable instance of an American ship, commanded by a Captain **Fairfield**, the name of which is not recollected, a trader between America and Europe, being in the middle of the Atlantic, with so little wind that the Captain was in the act of looking up at the flapping sails, and observing to the mate that they must carry on all they could to make a passage, when on a sudden, and without the least warning, the vessel was dismasted and sunk by a whirlwind, a few of the crew and passengers with the Captain escaping in one boat. The Captain was much blamed by some parties for having quitted the sinking vessel too soon, but the general opinion amongst nautical men was that no blame could be attached to him.* This would appear to have been very distinctly the kind of violent fine weather whirlwind of which we have all heard accounts.

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* I mention these details, as they may serve to trace out the accounts of this extraordinary meteor, which I am told were published in America, in full detail, in the newspapers of the day.

319. The bull's-eye *(olho de bove?)* or bull's-eye squalls, of which we hear and read on the coast of Africa, and which the Portuguese describe as first appearing like a bright white spot at or near the zenith, in a perfectly clear sky and fine weather, and which rapidly descending, brings with it a furious white squall or tornado, may be a strongly marked kind of these squalls. The white cloud is alluded to in **M. Goldberry's** account of the tornadoes, see p. 173.

In a large collection of logs and notes sent me by the Hon'ble East India Company, occurs the following, in a letter from Captain **Jobling** of Newcastle, who at the time alluded to commanded the ship *Kandiana*, which seems as it were to connect the whirlwinds with the white squalls and tornadoes on the one side, and it may be with the larger Cyclones on the other; though we have not unfortunately any veering of the wind noted. It is remarkable also, as occurring within the dangerous space which I have named the hurricane tract, see p. 34.

"On Sunday 4th October 1840, Lat. 13° South, Long. 86° 9′ East at 9 P. M., a hurricane commenced from North (without any warning; it was a dead calm at 8° 15′ P. M.), which carried away our three topmasts, jib-boom, and sprung the mizen mast, laying the ship right on her beam ends. It lasted with the utmost fury for four hours, and then moderated as suddenly as it commenced. My barometer rather rose than fell previously to it, and was never below 29.65. This was a most extraordinary occurrence, and so sudden that the men were up shaking the first reefs out, and I had only just time to call them in off the yards before the masts went over the side. I only gave the orders for them to come in from observing the extraordinary appearance of the water to windward. *It was like a solid mass of breakers coming down like lightning upon us.*"

In the *Bengal Hurkaru* of November 10th, 1831, is the following account of a whirlwind, which seems nearly similar to that of *Le Paquebot des Mers du Sud.*

DIAMOND HARBOUR, *Ship St. George,* CAPTAIN **Wills,** November 8th, 1831.

"I must now tell you of our misfortunes. On the 15th September, being in Lat. 35° 30′ South, and Long. 44° East, we met with a whirlwind, which in a minute carried away our fore-mast by the board, the main-top mast and mizen top-gallant mast, and we afterwards found our jib-boom and mizen-top

mast were sprung. Finding the vessel to steer well under jury-masts, the Captain pushed on for Calcutta instead of the Mauritius, and arrived in four months from pilot to pilot."

I have met with no farther details of this whirlwind.

320. **Horsburgh.** (Introduction, p. 8) says that he has passed through the vortex of water-spouts that were forming, and that there is a whirling motion. Mr. **Walker,** H. M. Dock Yard Plymouth, quoted by Colonel **Reid,** p. 492, says that he has sailed through a water-spout in the Bay of Naples, and that its rotation was with the hands of a watch. Both of these cases relate of course to small water-spouts, the following to larger ones.

321. In **Franklin's** letters there is a paper of extracts from **Dampier's** voyages, which was read at the Royal Society, and one of the water-spouts described in it, which appears to be cited by **Dampier** as an instance of the danger of their breaking, as it is called, over a ship, is well worth quoting here, as shewing that the sea water-spouts are really whirlwinds, and sometimes dangerous ones.

"And now we are on this subject, I think it not amiss to give you an account of an accident that happened to a ship once on the Coast of Guinea, some time in or about the year 1674. One Captain Records of London, bound for the coast of Guinea, in a ship of three hundred tons, and sixteen guns, called the *Blessing*, when he came into latitude seven or eight degrees north, he saw several spouts, one of which came directly towards the ship, and he having no wind to get out of the way of the spout, made ready to receive it by furling the sails. It came on very swift, and broke a little before it reached the ship, making a great noise, and raising the sea round it, as if a great house, or some such thing had been cast into the sea. The fury of the wind still lasted, and took the ship on the starboard bow with such violence, that it snapt off the boltsprit and foremast both at once, and blew the ship all along, ready to overset it; but the ship did presently right again, and the wind whirling round, took the ship a second time with the like fury as before, but on the contrary side, and was again like to overset her the other way, the mizenmast felt the fury of this second blast, and was snapt short off, as the foremast and boltsprit had been before. The mainmast and maintop-mast received no damage, for the fury of the wind (which was presently over) did not reach them. Three men were in the foretop when the foremast broke, and one on the boltsprit, and fell with them into the sea, but all of them

were saved. I had this relation from Mr. John Canby, who was then quarter-master and steward of her; one Abraham Wise, was chief-mate, and Leonard Jefferies, second-mate."

322. Next to this we may place from **M. Peltier's** work, p. 274, who has taken it from the Physico-chemical Institutions of Father **Piancini,** who had the accounts from an eye-witness, the following instance of a Mediterranean polacre, which was entirely enveloped in a spout in the Ionian sea, opposite to the gulf of Sydra. The relation is as follows—

"The wind was E.N.E. and against us. The sea was much agitated, the sky covered with very low black and thick clouds, which the day being far advanced, made complete night before the usual time. Also at once the wind changed to N.E. and we tacked to the Northward; all the sails were taken in except the four large ones. The wind changed anew, and the Captain tacked to the East, and the wind changed again. These changes arose from our approaching the place where the spout was forming. In an instant we were surprised by thick clouds which passed between the sails and the masts. This was the beginning and arrival of the spout. All sail was taken in as quickly as possible. But now the spout had come upon us, it united itself to the sea, and turned the poor polacre about like a wooden shoe. Her head was in a moment at the 32 points of the compass. We then felt a trembling or shaking from above downwards. Sometimes the wind forced the vessel against the sea, sometimes it lifted it up; as much so at least as its weight would allow. The wind having turned the vessel round continually, now began to heave her strongly on her side and on the sea. Then we felt that the vessel was raised forward and depressed abaft . . . . . We thus remained motionless, and trembling and praying during the whole time that the spout lasted, like a person at the bottom of a well, who is looking upwards. The action at last ceased suddenly, together with the violence of the wind, and the spout left us in quiet after a terrible farewell shock. It left us at a distance afterwards, but all the night we had a heavy sea, with strong variable winds."

Making every allowance for the vivacity of an Italian imagination, and the alarming predicament in which the narrator certainly was, there is still here much which gives us an insight into what the state of a vessel so situated must be, and what precautions should be taken in such cases; as well as into what electric processes are going on within a water-spout, for every person acquainted with electricity, will see in the apparently fanciful liftings and throwings from side,

to side of this vessel, and of the one cited by **Dampier**, exactly the alternate attractions and repulsions so familiar to every electrician in many experiments.

323. We have seen that whirlwinds on shore certainly so far resemble water-spouts, that they lift water and fish. There is equally no doubt, that when sea water-spouts reach the shore, they become whirlwinds, of which the following are very clear and distinct instances.

My friend Captain **H. Howe**, Naval Assistant to the Commissioner of Arracan, writing from Kyoo Phyoo on the 12th May, 1843, says—

"In the absence of any thing more remarkable, I may mention to you the interest we all derived from witnessing the formation, and full action of four large water-spouts, all appearing at the same time, so that the eye could not sufficiently dwell on as it were, and admire the one, without being called off to observe the other. The 9th instant, was ushered in with hot sultry weather, and a heavy dense cloud hanging over the offing, from which very suddenly four cones made their appearance, and rapidly elongating, reached the surface of the sea, which under their influence acquired a circular motion; an immense column of whirling spray joined on to the lower ends of the cones, being driven along with each of them before the wind, right on to the shore, from a distance of about 3½ miles. Only one of them, however, reached the land, and that went tearing and revolving along, taking up clouds of dust and leaves, and going at a rate of at least four knots, and had any thing light been in its way such as a light shed, or an insecure roof, I have no doubt it would have carried it off. The description of a water-spout in **Horsburgh's** Directory so exactly tallies with our observations here, that nothing new is left to be said, and to enlarge on the subject would be mere plagiary, but I am induced to notice these phœnomena from the unfrequency of four large ones being seen in such perfect action at once, and so near to the observer; I have seen hundreds of them at sea, but they generally dispersed before fully formed, and this made the present ones appear the more remarkable; the sides of the several cones also presented a curious spectacle, dilating and collapsing as though emptying themselves of their surcharged weight of water; they were in full force for about 20 minutes, and after they had disappeared, we had a refreshing thunder storm with rain."

In a subsequent letter Capt. **Howe** states that the gyration of the water-spouts, was with the sun, or ↻ which is the direction for the Southern hemisphere.

324. It would seem from the foregoing, and from several instances given by **M. Peltier,** in his work, as also by **Franklin,** in a letter from **W. Mercer,** describing the water-spout at Antigua, which was a spout (one of three) which came up the harbour, and on "landing" became a mischievous whirlwind, moving houses and killing three or four persons by the falls of timber, that the fine weather water-spouts, are certainly whirlwinds when they reach the shore, but there is another class of them which I have not seen adverted to yet, but which the sailor should be made fully aware of, and which form altogether a new phœnomenon. These are the water-spouts or whirlwinds, which appear in the midst of severe Cyclones, of which the following are instances:

325. In my IIId. Memoir, Journal Asiatic Society, Vol. IX., in the log of the Barque *Tenasserim,* Captain **Tapley,** lying to off Cape Negrais, towards the close of a severe Cyclone,* is the following—

29*th April* 1840.—"At 1 P. M., up foresail, a very threatening appearance to the Southward. *At* 2-30, *wore ship to the S.W., at the same time to clear a whirlwind. By this manœuvre allowed the whirlwind to pass about* 200 *yards on the lee quarter.* Furled every thing to a storm main try-sail and hove to again."

This phœnomenon, I thought so extraordinary, that I addressed some queries to Captain **Tapley** on the subject. His reply is as follows—

"I have much pleasure in giving you answers to your inquiries as nearly as I can. At 1 P. M., 30th April, by Nautical time, (but by Civil time the 29th) a very threatening appearance to the Southward ; ship's head East, a terrific squall from the S.S.E. rising very rapidly, and having a very blowing appearance. When the squall was within two miles of the ship perceived a heavy whirlwind flying to the N.N.W. ; immediately wore ship to the S.W., or first to the Westward, to give the ship way through the water ; by doing so, allowed the whirlwind to pass the ship ; when passed, brought the ship to the wind, clued every thing up, and furled all. Soon after, about 10 minutes, the squall took the ship from the S.S.E., ship's head about S.W., blowing a complete hurricane, could not see half the length of the vessel on the water, owing to the tops of the sea being blown by the force of the wind, and a deluge of

* She was in, and standing to the Northward out of the edge of the Cyclone in which the *Nusserath Shaw, Marion,* and other transports of the China Expedition were dismasted and suffered great damage.

rain at the same time. I cannot remember how it was turning as we were anxious to turn out of it; it was going round at a furious rate, and disappeared in the rain to the N.N.W. I do not recollect any lightning at the time. We could not discern it until it had approached pretty close, and then the most we saw was the foaming of the water travelling up in a rapid progress. The day had been fine and a little clear for a few hours, but blowing hard. At the time this squall appeared, the sky all round assumed a threatening appearance, and squalls gathered and rose rapidly. After this severe squall, the weather kept bad during the remainder of the 24 hours."

In my Tenth Memoir, Journal Asiatic Society, Vol. XIII., in the log of the *Coringa Packet*, which vessel experienced a small, but severe Tornado-Cyclone off Trincomalee, while a large one was crossing the Bay a few degrees to the North of her, is the following account of it.

"19*th May* 1843. Daylight blowing a tremendous gale from E.b.S., the sea running in pyramids, and the ship labouring very heavy. 8 A. M. Barometer 29-30. 10-30 A. M., *a very large water-spout formed within about two cables length from the ship, passed across her stern, and hove the ship 'round head to wind; the fall of water on board was tremendous. Observed the barometer to rise immediately to* 29.45."

326. But the most tremendous of these whirlwinds or water-spouts occurring in the midst of Cyclones, is the following from the log of the barque *Duncan*, from Cadiz to Calcutta, which vessel experienced from the 28th to the 30th March 1846, a severe Cyclone in Lat. 14½° South, and Long. 79° to 78° East (Track ii on Chart No. II.) In the remarks of the 29th, Captain **Fawcett**, says—

"About 6 A. M., a most singular phœnomenon occurred. About two miles astern of the ship, the water was rushing and foaming up to an astonishing height, gyrating round the centre, and passing the track of the ship with astonishing velocity. *The diameter or breadth of the vortex of this whirlwind could not be less than two miles from the appearance of its spread; and how far the circle of its attraction extended, I was unable to guess.*"

The ship was at this time lying to with the wind at N.E.b.E. and her head to the N.W., so that this whirlwind which bore to the S.E. of her could not be the actual centre of the Cyclone, which in that hemisphere was to the Westward of the ship. The Simpiesometer which was well observed during the Cyclone seems to have given no particular indication at this time.

A whirlwind or water-spout (or a compound of both, which this seems to have been) of two miles in breadth must bring with it however an awful risk to masts, and to ships of which the hatchways are badly secured.

327. But we have even an instance of the transformation of a water-spout into a *storm*, though the word used being *tempête*, we cannot affirm that it was a Cyclone. The following is translated at length from **M. Peltier's** work, p. 258, in the Chapter giving the detailed relations of water-spouts.

ATLANTIC OCEAN NOT FAR FROM THE GAMBIA RIVER, 2nd September, 1804.

No. 41. Day and night water-spout (*trombe*), which lasted fourteen hours; a luminous column in its whole diameter; complete calm before its formation; sky excessively overcast; frightful storm (tempête) during its existence; pleasant breeze from the West afterwards.

"I owe to Doctor **Leymerie** the account of a spout (*trombe*) which he saw on the 2nd September, 1804, being on board of the cutter *Le Vautour*. This vessel sailed with letters of marque (a privateer trader?) and was coming from Cayenne towards the coast of Africa; they were not far from the Gambia when this meteor occurred. Before the spout was formed it was a dead calm. The preceding days had been very hot, and since the morning the sky had been covered with numerous thick clouds. The cutter was chasing an English slaver, when all at once they saw a column of water of about a hundred metres* which rose up from the sea and went upwards to join a column of vapour which descended from a cloud. At this moment the calm ceased and the tempest (*tempête*) began to blow with violence. We have preserved Doctor **Leymerie's** expression of a column of water though we are persuaded that it was not liquid water of which it was formed, but water in the state of a dense vapour, as has repeatedly been shewn. This column was luminous in its whole diameter; it had a phosphorescent appearance and was slightly yellow or fawn-coloured. The sea itself was on that day resplendent with light, and the vessel left after it a long track of fire. This spout as well as the storm (*tempête*) which accompanied it, lasted fourteen hours, and caused numerous shipwrecks on those coasts. It did not terminate till four in the morning of the following day: so that it had commenced about two in the afternoon, and had lasted a great part of the night.

Observation (by **M. Peltier**). I think that the luminous state of the cone of the spout would be often observed if this meteor occurred frequently at

* About 328 feet; and in diameter no doubt is meant, by what follows, though not so expressed.

night from the preceding facts,* the column was formed of vapour and not of liquid water, the phosphorescence of the waters of the sea exists no longer in the column; the light by which it was pervaded can then only be derived from the infinite (continual) discharges which constitute an electric current and not from a true phosphorescence."

328. We may remark on this, as to the light, though it is strikingly analogous to what we know has taken place in some Cyclones (p. 166, Note) that, allowing the water at the base to have been mere vapour, if it rose from the sea it might undoubtedly, even in that state, be still phosphorescent; but apart from this, the storm following or accompanying the spout is always of very great interest. Unfortunately being a privateer, and apparently a colonial one, there is no hope now of obtaining a copy of the *Vautour's* log by which we might clear up the question of what kind of a storm *(tempête)* it was; and if, which also is doubtful, the *spout* lasted all the time; for we can hardly suppose in spite of what is said, that the vessel remained in sight of it.

The expression used, and which I have exactly translated, may be intended to convey that the spout was seen in various places by the vessels shipwrecked?

329. We must not pass by another peculiarity in wind and water-spouts, which is, that great numbers of them are described in the different relations collected by authors, as being accompanied by *noises* of all kinds and degrees; "from the hissing† of a serpent to the noise of heavy carts on a rocky road," says **M. Peltier**, or of "a cascade falling in a deep valley," say other accounts; and these noises are usually more violent on land than at sea.

330. In reference to the peculiar noises heard at the passage of the centres of Cyclones § 212 to § 216 p. 159 this is remarkable, and deserving of future attention; as is also the fact frequently referred to by the accounts given in **M. Peltier's** work, that the sea often shows, at the commencement of water-spouts and even of tornadoes,

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* Adduced by **M. Peltier** in his work, from which he concludes that the lower half of the column of a water-spout is not water but dense vapour; in which he agrees with most other writers.

† **Horsburgh** (Introduction, p. VIII.) mentions the hissing.

a remarkable agitation like a boiling *(bouillonement)*. This on a larger scale may be a pyramidal sea, if we allow electricity to have any part as the cause, or even as the effect, of a tyfoon.

331. It may be useful here to give some account of **M. Peltier's** able work, *Sur les Trombes**, which not having been translated into English (that I am aware of) is probably unknown to the majority of my sailor-readers at least; yet its contents are often so essential to the right understanding of much that we have to set forth in this Part, that I should not fairly accomplish my purpose of placing before the seaman, in a plain and intelligible form, all that is known of our new Science in all its relations, and of indicating what has yet to be enquired into, did I not make him acquainted as briefly as I can with the contents of the work.

332. **M. Peltier's** view then of land and water-spouts (or of whirlwinds and water-spouts, which the French class together in their word *Trombe*, but of which he perfectly preserves the distinction in his descriptions and experiments) is, that they are, "but transformations of another meteor." And this meteor he affirms to be an electric action; not simple, but one compounded of the electric state of the cloud, and of that of each separate globule or particle of air or vapour, composing it, and generally speaking analogous to thunder-storms in many points, but acting with greater intensity. He affirms and shows by many proofs, that the visible clouds above are not the only ones in the atmosphere, but that there are also invisible (because transparent and uncondensed) ones; which like the others may be electrically charged, and produce the same phœnomena, though perhaps in a weaker degree.

333. **M. Peltier** proceeds then to point out what are strictly the essential phœnomena to constitute a *trombe*, (whirlwind or waterspout), and what are those which do *not* appear to be so, or which occur only incidentally; and amongst these last he places the whirling motion, and currents of air forming a whirlwind, as not being constantly observed in them.

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* *Observations et Recherches experimentales sur les causes qui concourent a la formation des Trombes. Par M. Ath. Peltier.* Paris. H. Cousin 1840.

334. He then proceeds by various ingeniously contrived and instructive electric experiments, by conductors with balls and points, or a single point, to reproduce upon leaves of copper-foil; dust and smoke of resins over water; and upon water alone; gyratory movements; repulsions *from* the centre; *horizontal* and vertical whirling clouds in the smoke; bosses or umbels of water*; deep depressions in it†; the raising of light bodies; the production of vapours; and even vapours of pure water from an acidulated mixture; accounting thus, as he fairly observes, for all the essential and usual phœnomena of spouts. He adduces then many relations of land and water-spouts which have shewn all the electric phœnomena, and concludes the first part with tabular statements of spouts *(trombes)* and of all other analogous meteors, so as to give a complete and highly convincing body of evidence in a small compass. The second part of the work consists of the detailed accounts of the various instances cited in the tables. The whole is indeed well worth the perusal of meteorologists and of seamen, for the numerous points of relation which it shews with Cyclones, and of enquiry which it suggests to every intelligent man.

335. **M. Peltier** has collected in his work in three tables, 137 accounts of water-spouts, beginning with **Thevenot's** in 1674. The results of these, of which we should note that 66 are properly *water*-spouts seen at sea, or on lakes, rivers, &c., while the rest are whirlwinds or *wind*-spouts, or electric columns acting on land, he states to be as follows—

"In the 137 instances cited—

37 Spouts‡ have had a gyratory movement, continuous, or with some intermittence or but for a short time with others; frequently only a portion of the vapours had this gyratory movement.

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* An experiment known since the days of the **Abbe Nollet** (a contemporary of Franklin) remarks **M. Peltier.**

† Often seen and noted in accounts of water-spouts at sea, and from **M. Peltier's** experiments, it would seem that alternate risings and sinkings can be produced, forming miniature waves.

‡ As just remarked, the French use the word *Trombe* to express both a water-spout, and what we should call a whirlwind. Thus, they would have no separate word to express the sea and shore-spouts described at pp. 245, 246, assuming as is there shewn, that the meteor is but one and the same.

25 are noted as having no gyration, or this may be directly inferred from the details.

The accounts of the other spouts *(trombes)* not specifying if there was or was not any gyration, the presumption is in favour of the negative, for an account indicates *what exists*, and not what does not exist.*

33 are stated to have occurred during a more or less perfect calm : we might add to these, those which have taken place during a light wind or a regular breeze blowing from one side only.

56 have been accompanied by thunder, lightning, or electric signs of this kind.

10 have occurred beneath a cloudless sky.

19 have exhibited vapours ascending within the column, 7 have shewn descending vapours.

15 accounts are relative to several water-spouts together.

7 spouts have been double, triple, &c., *(multiple)*; some have divided and reunited.

15 have carried up liquid water, and some accounts shew that the sea was hollowed out below in a conical shape.

3 water-spouts at sea in which ascending vapours were distinguished, having been crossed by ships, have discharged *fresh* water.

6 spouts took place at night.

3 were formed between the clouds."

336. There appears then no reason to doubt, that most, if not all water-spouts are in point of fact whirlwinds, i. e., are whirling round at the visible part or column, and that they are probably surrounded, as Professor **Œrsted** thinks, by an invisible column of air which is also a whirlwind, and this view is moreover confirmed by several examples, adduced by Col. **Reid.** I believe also, that most sailors would be able to corroborate it. The last well recorded instance we have of its being clearly and indubitably shown, is that of the water-spout which passed through Sir Robert **Stopford's** fleet near Vourla, of which the rotation was clearly seen; it also "shook the ships' sails violently, and small articles were whirled about as in a land whirlwind." **Reid.**

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* **M. Peltier** forgets here that, in relations of all kinds, every thing depends on the accuracy, and memory, and habits of mind of the observer and relator ; and that in a number of narrators, some from negligence, or from supposing the turning round to be admitted of course, or as of no moment, might omit to state it.

As to the direction in which they turn, this seems to be quite uncertain, as far as all authorities go.

337. The great water-spout which fell on the Island of Teneriffe, in Nov. 1826, appears by Mr. **Alison's** relation in the Philosophical Magazine, to have been at once a water-spout on the island, discharging enormous volumes of water, and tearing up the soil, and even the tufa rock, into deep ravines, while numerous globes of fire were seen at sea and on shore and a true Cyclone was blowing out at sea. How far all these were connected it is impossible to say, from the imperfect nature of the accounts, but the circumstance of their occurring together, and on and about a volcanic island, is of great interest.

338. **Commencement and breaking up of Hurricanes.** The most natural questions which arise in the mind in considering these meteors, are the constantly recurring ones of " *Where and how do they begin?*" " *Where and how do they end?*" and we are yet involved in utter mystery as to these two essentials to the history and right understanding of Cyclones. It is clear that there must be *some* beginning, and an ending *somewhere;* but none of our researches have as yet disclosed to us any thing on this subject beyond remote conjectures, and vague probabilities.

339. Mr. **Thom** thinks, p. 163 to 164, that in the formation of a Cyclone " it may embrace several small vortices formed by the gradual effects of the wide exterior circle in withdrawing air from the internal space."

The following instances, both of which have occurred in the Bay of Bengal, and at or about the commencement of a Cyclone of great severity, seem to me worth recording. The first is from a letter from Captain **Buckton,** of the brig *Algerine,* printed in my Seventh Memoir, Journal Asiatic Society, Vol. XI. This vessel appears, not improbably, to have had a Cyclone overhead, which crossing the Bay from the Southern Andaman to Point Palmiras, afterwards became the Calcutta Cyclone of the 2nd and 3rd June 1842. There must be an error in the reading or the Zero point of the barometer I presume? and that it was 29 and not 28 inches.

" On the 28th May, in Lat. 10° North, Long. 92° 26′ East, the sky became a perfect dense mass of black clouds, with the scud flying rapidly past from N.E., S.E., and W.S.W., the wind light, and the sea rising in bubbles, as if

the wind was blowing from every point of the compass, hissing and rising up in bubbles like a boiling cauldron. Here the barometer fell to 28.60. ; this being excessively low for so low a latitude induced us to make every preparation for severe weather. From this time until the 1st June, Lat. 15° 25′ North, Long. 87° 58′ East, experienced an increasing gale steady from S.S.W. to S.W. by W. with much lightning, and a very heavy appearance all round. The barometer rising and falling according to the strength of the squalls, or the preponderance of rain from 28.70 to 28.56. On the 2nd (civil time,) the gale increased so as to oblige us to lay to, the barometer having fallen to 28.45 (Lat. 17° 20′ North, Long. 87° 6′ East.)

"At 9 A. M., experienced a cross sea setting in from S.W., N.W., and N.E., the former preponderating; the rain pouring down in torrents, the gale increasing, and the squalls blowing with fearful violence from W.S.W., and shifting suddenly from that to N.W., N.N.W., and as far as North; the barometer gradually falling until it came down to 28.18; at midnight more moderate, the barometer up to 28.36. Steady gale from S.W.b.W. decreasing toward noon when Lat. 19° 10′, Long. 86° 42′ so as to enable us to make sail 3 M. P., until 11h. 30m. P. M. of Friday, when the barometer again fell to 28.20, during a most severe squall from N.W. False Point was then bearing about N.W. 12 miles."

340. The next example is that of the ship *Vernon*, Captain **Voss**, from England bound to Madras, in a note dictated to me and subsequently corrected by him. It commences on the 26th November 1845, and at this time, or rather between the 27th and 28th severe Cyclones were raging both in the Northern and Southern hemisphere, and between the same meridians, though distant about 13° of latitude from each other, with a heavy Westerly monsoon blowing along the Equator. These Cyclones form the subject of my Eleventh Memoir, (Journal Asiatic Society, Vol. XIV.) and on the 28th, the *Vernon* was distant at noon about 400 miles from the centre of the nearest Cyclone then raging, though in two days more another (for there were two in the Northern hemisphere) was developed on this very spot. The *Vernon* is a remarkably fine frigate built East Indiaman of 1,000 tons, belonging to Messrs. **Green** and Co.

"Ship *Vernon*, *November 26th* 1845. It began to get gloomy and the clouds were whirling about above in a remarkable manner, wind variable from the Eastward below, and in puffs. Barometer not much under 30.00 (about 29.95.)

"*On the 27th.* Barometer had fallen to 29.85, dark and gloomy weather, still variable from N.E. to East with squalls, confused swell all round, clouds very low and lowering, with appearance of bad weather, Lat. 9° 6′ North, Long. 85° 0′ East, Bar. 30.0 Ther. 83°, clouds still moving in all directions; kept snug at night; very squally with rain from East to N.E. sea getting up.

"*On the 28th.* At Daylight wind, Bar. at 29.70, every appearance of bad weather, wind increasing, variable and threatening from E.S.E. to N.E. Double-reefed, &c. and sent down royal yards towards noon. Lat. by acct. 10° 46′ North, Long. 84° 7′ Bar. 29.80 Ther. 78°. We appeared to have got between three clouds; wind then came in hard squalls (ship with top-gallant sails furled and courses up, topsails on the cap and reef-tackles close out.) Forked lightning but not much thunder, squalls from N.E. then North and N.W. and right round, and thus the ship went round *six turns in about* 30 *minutes* following the wind, with after yards square and head yards braced up. The rain falling literally in heavy sheets, so that it was hardly possible to stand; the men obliged to hold on, decks half full of water. The wind not moderating with the rain, but blowing in severe gusts. After this the wind steadier but still from about N.E. to E.S.E. with sharp squalls obliging us to lower the double reefed topsails, very dark and gloomy.

"*On the 29th;* more moderate, still blowing hard with gloomy weather till sunset, when it became finer."

341. With the foregoing examples, and remembering what has been said with respect to whirlwinds and water-spouts, we may venture to consider a little how Cyclones *may* commence. It is much too soon to affirm, or almost to suppose, that they *do* commence in any one particular way, and we must remember also that even to describe clearly the mode or modes of action (for there may be more than one) by which they commence, could we do so, does not at all affirm any thing of what *causes* these actions. In a word, that we are here essaying to describe, or suppose, effects and not causes; and if I give any space to the discussion of what we are yet so imperfectly informed of, it is because I think it very essential that the thoughtful and careful mariner, as well as all who desire to aid us, should, to use a sporting metaphor, be put upon the tracks and scents by which they may furnish us with useful notes.

342. A Cyclone, then, must commence, at sea, beneath, upon, or at some distance above, the surface of the ocean. That it commences

beneath the ocean we have no sort of evidence or of analogy to lead us to suppose: and we are therefore reduced to the last two cases; i. e. that it commences at the level of the ocean or in the atmosphere.

343. Now the proposition that Cyclones begin at the surface of the ocean is certainly a highly tenable and probable one; so far as that we assume that a vortex of any size, or form, or force, may be produced and sustained for any length of time, by counter streams of wind, of sufficient force and dimensions, meeting side by side, and thus generating, as in water, a circular motion. If they met direct in front of each other we should look rather for a calm, or at most a succession of small whirls.

But beyond this we are stopped; for we are much at a loss to imagine how two mere monsoon gales *can* generate forces so far above their own velocity, and then this theory affords us no sort of clue to the progressive motion, which is as extraordinary, if not more so, than even the rotation.

344. One would suppose also, that we should have had, far more frequently than we have, some traces of commencement in segments; as in Mr. **Rechendorf's** dust whirlwinds, p. 165, or in vortices as in Mr. **Thom's** supposed case. We have also another difficulty of no small magnitude in this hypothesis (supposition) that the Cyclones are whirls produced by opposite or lateral streams of air at the meeting of the trades and monsoons; which is, *that it seems to prove too much;* for, if we admit this, why not also allow that, at least for the six months in which a monsoon crosses, or is opposed to, the trades, there should be a constant succession of the Cyclones? while it is notorious that they only happen during certain months in most parts, and sometimes none occur in the season, and they are moreover, to all appearance, and as far as surface winds are concerned, generated both *within* the trades and without their limits and those of the monsoons.

345. The remaining possibility then is this—*Are they originally formed above the earth, and do they descend horizontally (as horizontal disks) or inclined at an angle, and of a considerable size at first?* for we know that they both dilate and contract, as whirlwinds and water-spouts do when in action, at the surface of the earth.

346. Every theory which pretends to account for any natural process, such as a meteor like our Cyclones, should account fully for or admit *all* the principal phœnomena of it. If it does not do that, it cannot answer the questions put to it. Let us see how far the theory, that Cyclones may be formed in the atmosphere and are in fact disk-shaped vortices, descending from above, will do so.

1. The Cyclones *may* be so formed, either electrically or by the mere dynamical (mechanical) forces of currents of air causing whirls or whirlpools.

2. They may be formed, both at the sides and at the upper and lower surfaces of different strata of clouds. In the last case the action is more probably electric than in the former.

3. Being once formed and in action, they may either rise higher, or descend or plunge downwards, from various causes.

4. They may also be admitted to extend themselves greatly, or to diminish in diameter; and finally to exhaust themselves by their own violence; or to break up and disappear on reaching the land from seaward.

5. They may be supposed as in the analogous cases of water-spouts to have a calm centre, however this is formed and sustained.

6. They might have great developments of clouds and rain, and sometimes of electricity, both at the centre and circumferences.

7. They would be *more* apt to be generated in parts where the upper currents of the atmosphere, of various temperatures, degrees of moisture, electric states and other differences, may be supposed to meet in large bodies, than in those parts where perhaps these currents are more regular, and less liable to be in states widely differing from each other, or to be interfered with by their contact with, or approach to the earth, and its constant electricity.

8. They might also, from many causes, not be disks parallel (truly tangential) to the surface of the globe, but be inclined forwards.

9. As they *are* certainly disks, if we suppose them at first truly horizontal above and below, they must, when pressed down to contact with the earth over a space of 300 miles, be much thinner at the centre than at the edges. A flat disk, of 300 miles and ten miles high at its edges, would be but 7-2 miles high in the centre;

supposing that it did not curve, but remained horizontal above and only curving below; becoming thus what is called in optics a plano-concave lens; and one of three miles in height at the edges, only two-tenths of a mile thick at the centre.

10. If generated above the surface of the earth, and by electric causes, there might be, according to the nature of the electric action, as we have seen by **M. Peltier's** experiments at p. 251, a disk or umbel of water raised at the centre, which would move onwards with the electrified clouds above; or in some cases there might be a depression and circular currents.*

11. If so generated there might be more than one Cyclone formed at the same time, or they might divide or unite, and a Cyclone might at first, like a water-spout and *its* cloud be stationary, and then move on at a greater or less rate.

12. A Cyclone in full action, being as we have shewn a disk only, might be lifted up by an obstacle, as mountains, hills, &c., and cross them as well as intervening vallies, so as to be seen by the inhabitants "whirling about in an extraordinary manner,"† and then descend again to a low flat country or on the ocean. There is no doubt that this has very frequently occurred in storms crossing the Peninsula of India, or travelling inland at the head of the Bay of Bengal.

13. If a Cyclone was formed, as whirlwinds and water-spouts certainly are, above, and from the same causes, it might like them, produce in a stronger degree, and especially towards the centre, peculiar noises which in the water-spout, are described as rumblings and hissings, see p. 249, and in the Cyclone as "roarings," "thunderings," "yellings" and screamings."

14. The unequal duration of the different sides of a Cyclone, may also in a great measure be accounted for by supposing them to be descending disks. The fact that the front or advancing side of a Cyclone is almost always of much longer duration than the latter part, is too well known to require any instances in proof of it.

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* **M. Peltier's** were *outward* circular currents, it should be noticed.

† This expression occurs in one of my Memoirs, and the equivalent to it in others, and in those of Mr. **Redfield.**

15. Now if we suppose a disk to descend horizontally, no doubt its force and duration may be equal on all sides; but if we suppose it at all inclined, in a plane of which the lowest part is in front, we must equally suppose a part of it lifted up from behind. We know nothing of the actual facts, and can therefore only adduce suppositions.

347. We thus see that if we suppose a Cyclone to be formed in the atmosphere between strata of clouds, in the same or opposite states of electricity, and then from any cause to descend or settle down upon the ocean, it would fulfil all the conditions which we have set down; and these are not only the principal, but most of the secondary ones. It is very true that these might be also fulfilled by Cyclones formed at the surface of the earth or ocean, by contrary or sidelong winds, but then we have the objections that I have before cited, p. 256; i. e., that they should be constant during the opposing or crossing monsoons, and should occur much more frequently than we know them to do. I desire to be understood here as having been simply desirous to set forth the probabilities on both sides, and only as offering this one amongst others which may be proposed; waiting for evidence to confirm or refute it: In other words, this theory is yet "lying at single-anchor."

348. The relation of **Mr. Redfield's** explanation of the fall of the barometer, and of the actual barometric curves, as shewn by our Plate at p. 193 to this view of the possible mode of the origin and continuance of Cyclones is closer than would be at first imagined;* for we may easily suppose a storm-disk, formed above, and not yet descending to the surface of the earth or ocean, but still affecting the Barometer. At its first formation, it is clear, that it may be, if formed between two horizontal strata of clouds or gases, very thin; or if formed as a vertical column between the *sides* of masses of cloud or gas, to be yet very short, till it extends and thickens (or lengthens) before it reaches the earth; and all these modes of origin, increase, and action might go on with fine, or at most in cloudy weather below, and be only indicated by the Barometer; and when

* I am aware, that I am, in part, supporting here one theoretical view by another, and that such is but weak scientific logic; but the barometric curves are indubitable facts, and the calm centres are equally so.

the Cyclone descended, its effects would be felt at once in various places at great distances from each other, and this seems to be what really occurs; for we have nothing which will allow us to say that we have traced a Cyclone from a mere whirlwind to a full storm. We may even go a step farther, and suppose that as (apparently) the greatest condensation is at the outer part of the circle, the disk may reach the earth in a curved form, so as to be first felt at the outer zones. All this, it is true, is conjecture and highly uncertain, but observation may do much for us in clearing up many of the questions I have adverted to, and a single one may throw a flood of light upon a dozen others.

349. In reference to this, I translate from the Italian of **Ramusio**, not having the original Spanish work to refer to, the following remarkable passage from the *Historia General de las Indias* of **Fernando De Oviedo**, Book VI., Chap. III., describing the great Hurricane of St. Domingo in 1508, abridging it a little in matters not essential to our purpose, and distinguishing a few passages by italics.

"Hurricane (*Huracane*) in the language of this Island means properly an excessively tempestuous storm, for indeed it is nothing else but a violent gale together with rain.

"Now it happened that on Tuesday the 3rd of August 1508, (Father **Nicolas Oviedo**, being then governor of the island), that about noon, an exceeding great wind with rain came on at once, *which was felt at the same time in many sites in the island*, and there arose from it suddenly great damage, and many estates were ruined. In this city of St. Domingo, all the straw houses were prostrated, and some even of those of stone were much shaken and damaged. At Buena Ventura, all the houses were destroyed, so that for the many who were ruined there, it might more properly be called Mala Ventura.*

"And what was worse and more grievous, was that in the harbour of the city more than twenty ships, caravels, and other vessels were lost. The *Northerly* wind was so strong that as soon as it began to blow hard, the seamen did every thing in their power by laying out more anchors, and fastening by more ropes to secure their vessels; but the wind was so violent that no precautions could withstand it, every thing was carried away, and the force of the wind drove all the vessels, large and small, out of the port, down the river, and they

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* *Buena ventura* "good luck:" *Mala ventura* "bad luck."

perished in various ways. *But the wind changing suddenly to the opposite quarter, and with not less impetus and fury, blew from the South as violently as before from the North,* when some vessels were driven furiously back into the port, and as the North wind had driven them out to sea, so this opposite one drove them back to the port and up to the river. They were afterwards seen drifting down again with only the tops in sight above water. Many persons perished in this calamity, and the most violent part of the tempest lasted twenty-four hours, until the next day at noon, *but it did not cease all at once as suddenly as it came on.*"

The author then goes on to describe the frightful appearances and damage occasioned by the storm, and adds, that the Indians (and they were then a numerous people) said that they had frequently experienced hurricanes, but that neither they nor their fathers had ever before experienced the like for its extreme violence.

350. There can be no doubt, first, that this was a true Cyclone, and one of extreme violence, but the remarkable part of this relation is the stress which is laid upon the very sudden commencement of it in many places at once; and the Spaniards even at that early period (16 years after the discovery of America) had many settlements along the coasts, and probably far inland, for the gold washings and minings.*

If we suppose the Cyclone to descend as a disk, this sudden onset of its fury in many places at once is exactly what should occur, and its gradual cessation so clearly and pointedly contrasted with the sudden beginning, is also such a description as might have been written in our own days of a Cyclone of the usual diameter of those of the West Indies (about 100 to 200 miles, see p. 60) descending with its centre on the Mona Passage, and travelling along on an East and West track to the Westward, at a rate of 10 or 12 miles an hour.

351. So far as to the origin and continuation of these tempests. With respect to their termination, we may well suppose it to

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* In 1495, only three years after the discovery, the Spaniards were working gold mines at 60 leagues distance from St. Domingo. See **Ramusio,** p. 9, vol. III. **P. Martyr's** History.

arise from the causes above being exhausted* or from the storm's "rising up" or from its friction on the surface of the ocean or land, which must be a very considerable element in the exhaustion of the motive force.

352. We should not conclude these views, however, without remarking that while almost all the phœnomena of Cyclones can be accounted for by either mode of formation, i. e., at the surface, or far above it and afterwards descending, there is a great law which is wholly unacounted for by either of them, and this is the LAW OF THEIR ROTATIONS; so invariable in each hemisphere that we find nothing approaching to a doubt of it in all the numerous investigations which have been made; but we *do* find that the mere water-spouts and the dust whirlwinds, which we may suppose to be generated near the earth's surface, turn indifferently either one way or the other.

353. Now this constancy of revolution for the great Cyclones, and violent, though smaller, tornado-Cyclones, would incline us to believe that their motions are dependent upon some invariable system of atmospheric influences beyond the reach of mere terrestrial causes; and the dynamical theory (of the Cyclones being occasioned by opposite or crossing *forces* of winds) seems wholly to fail; even where its simplicity at first sight recommends it; for if we suppose a strong N.W. stream of air, and allow it to rush into the S.E. trade, so that it passes on the *Northern* side of a strong S. Easterly stream, the two may doubtless produce, at their sides, a whirl, which might increase to a Cyclone, revolving ↻ or with the hands of a watch, as in the plate given p. 159, by Mr. **Thom**; and if the forces continued, it might also continue for days together *in the same place*. But nothing here would account for its moving forward across the trade, and its doing this is much against the supposition that the forces sustaining it are the mere surface winds; for supposing a Cyclone to be so

* As a thunder-storm ceases, when the electricity of the clouds is discharged, which, admitting Cyclones to be electric phœnomena, offers a strong analogy: and we may note by the way that it also furnishes an argument against the dynamical theory; for as soon as the Cyclone is over, the monsoon again returns as before in opposition to the trade-wind.

set in motion in 10° South and 90° East, the N. W. stream of air must force its way across, and through, some 10 or 15 degrees of latitude, to be still acting in the same way when the Cyclone reached the Mauritius; and must moreover propagate a new kind of motion for itself, sideways, to follow the Cyclone on its track! and to continue to supply it with forces. If we say, that the Cyclone is set in motion by one cause, and then that it generates a force of some *other* kind, as electricity, to keep it in motion, we depart wholly from all good rules of scientific logic, and we had better at once go back to the *other* supposed cause—whatever that may be.

354. Again: If we take the N.W. stream of air to be blowing from the N.N.W., and the S.E. trade from the S.S.E. and to meet so that the N.N.W., stream of air is to the *South* of the S.S.E. one, it is clear that they may produce a revolution *against* the hands of a watch, or ↻; and we should then have a contradiction in the known law of revolution for the Southern hemisphere. We all know that trades and monsoons vary infinitely between the points from which they take their names.

355. From all these difficulties, as well as from that great one which arises from considering that the effects of opposing winds *may* tend after all to produce as much calm as storm, we are freed by supposing the Cyclone to form above, and to descend as a whirling disk to the surface of the ocean; when as Mr. **Thom** remarks, "their diameter is (may be) from 400 to 500 or even 600 miles." With respect to the rotation, also, we may then easily allow that *if* they are formed far above us, and are mainly electric phœnomena, then they may be subject to influences and laws—the influences and laws of the electric state of the atmosphere at great heights—of which we are as yet as profoundly ignorant as we were of the electricity of steam ten years ago.

356. For the present, then, we must content ourselves with carefully registered observations, and these aided by the resources of science, may one day reveal to us the true cause or causes of Cyclones, as the carefully registered experiments of **Franklin** did to him the magnificent mystery of the lightning. We cannot in this *make* the experiments, but we can vary them a little by trials, and our business is to observe them patiently and carefully in all their phases.

357. A remarkable, and at first sight a very strong objection has been raised to the whole rotatory and progressive theory by asking, *how is it accounted for; if we suppose a body of air to be at the same time whirling round and moving forward; that the side which is moving in its rotation in the same line with the track, has not the wind of double, or treble, the force of that in the opposite side? Since it must have at the same time a double set of forces, i. e., that of the rotation, and that of the progression acting upon it.*

358. This is simply enough answered if we suppose the whole Cyclone to be an electric meteor, composed of one, or many, close and *nearly* horizontal, but yet slightly spiral streams of electric fluid descending thus from the higher regions; and in its (or their) descent giving rise to currents in all the air it successively passes through, but not carrying this *same* air forward with it. It is evident that such currents might be spirally inwards or outwards, and we know from **M. Peltier's** experiments, quoted p. 251, that such rotatory currents can be created, both in the smoke of resins and in water, by electricity.*

359. It is evident that the objection quoted above, tells with great force against the dynamical theory, or that which would suppose Cyclones generated at the surface by the forces of crossing currents of wind; becauses this affirms, that the whole body of the whirling Cyclone is supplied with its air (wind) by these currents; which then begin to move onwards, the streams of air doing the same, and that side of the circle which has its motion with the path of the Cyclone, to be therefore moving at a highly increased rate. We have also the difficulty of getting rid of the huge volume of air which by this theory must be at every moment poured in to supply the forces of the Cyclone, and for this Mr. **Espy** and Mr. **Thom** assume their up-moving currents.

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* I do not overlook the fact, that in the smoke the whirls were both horizontal and vertical, and that the currents in the water were, though circular, *from* the centre outwards; but **M. Peltier** remarks in more than one place on our imperfect means, and on the extremely insignificant scale on which we can imitate the processes of nature, and that when we come to those of the atmosphere, we are forthwith confined, for the most part, to experiment in and upon the air at the surface only.

360. It appears to me that a simple, flattened, spiral stream of electric fluid, generated above in a broad disk, and descending to the surface of the earth, may amply and simply account for the commencement of a Cyclone? and that its gradual propagation onwards, in such direction as the laws of the forces generating it in the upper regions may give to it, will *as* simply account for its continuance and progression? and the exhaustion of the forces for its termination? And nothing of all this is gratuitous supposition; for we have all seen, if we have not carefully remarked, the actions of opposing thunder clouds and storms, which *must* be generating some action somewhere; their passage over great tracts of country and appearance over hundreds of places at once, or sucessively, which is certainly like a descent and a progression, and which can be foretold, and vaguely accounted for, and finally after a longer or shorter duration their disappearance. If we are asked with all this, *why* the effect of a stream of electric fluid should produce storms of air (wind) so as to form Cyclones? we must reply that as yet we only suppose that it is so—and in this as in every other theory wait for farther facts to guide us to a new one; or to confirm it. It may be remarked also in reference to what I have said at p. 258 § 14 on the unequal duration of the sides of Cyclones, that this also may be perhaps accounted for by assuming, as I have done, the Cyclone to be formed by a spiral stream of electric discharges, for however flattened the descending spiral may be, one part of it *must* be lower than the other, and this may be on the advancing side. It must also part with more of its electricity to the ocean on that side, and thus have less for the forces required in the following side of the whirl.

361. The general impression which evidently exists from China to the West Indies, and which we find from the days of Columbus* to our own, in all the "Hurricane Countries," that however threatening the weather may appear, there will be no Cyclone, *if it thunders* as well as lightens *at the commencement*, is favourable to the view of the Cyclone being a purely electrical phœnomenon. For if we conceive a disk to be formed or forming, and to discharge its electri-

* In the old Spanish relations.

city *before* it descended, then we might expect both thunder and lightning. If, on the contrary, the discharge only took place when it *had* descended, it would then be the silent transfer of vast quantities of the electric fluid from the clouds to the earth (or vice versa) creating the circular currents of air which **M. Peltier** has shown, can be so generated.

362. Mr. **Redfield's** description of the clouds during a Cyclone, p. 217, adds also some probability to this view of their being formed above and descending as disks to the surface of the ocean; for the true disk, we may suppose to be the great sheet of stratus cloud which he describes; not in actual contact with the earth, but at that distance from it which would induce the discharge, and that the Cyclone is nothing more than the effects of that discharge; of which the wind and the whirling and fast flying clouds (cumuli and broken strata) and the rain are the effects. We evidently *see* this in hail storms, though these *may* be phœnomena of a different class.

363. We may advert here also to some other effects which have been undoubtedly felt close to, or at the centres of Cyclones, and which it is very difficult to account for, except by the agency of electricity. Amongst these are the accounts given by **Mr. Seymour,** master of the brig *Judith and Esther* in his letters, pp. 74 and 76, of Col. **Reid's** work, where he states that when thrown for the third time on their beam ends at the centre,

"For nearly an hour we could not observe each other, or any thing, but merely the light; and, most astonishing, every one of our finger nails turned quite black, and remained so nearly five weeks afterwards."

And again writing to Col. **Reid** in explanation, he says—

"Thirdly, as to the cause of not being able to see each other?

"The cause of this I cannot well tell; but while running before the wind the vessel was hove the third time on her beam-ends, and while on her beam-ends, the atmosphere had quite a different appearance, darker, but not so dark that (I should imagine) would hinder one from seeing the other, or from seeing a greater distance, were it not that our eyes were affected. It was about this time our finger-nails had turned black; and whether it was from the firm grasp we had on the rigging or rails I cannot tell, but my opinion is, that the whole was caused by an electric body in the element. Every one of the crew were affected in the same way."

WILLIAM SEYMOUR.

364. Analogous to this is the following from my Tenth Memoir, Journal Asiatic Society, Vol. XIII., on the Madras and Masulipatam Cyclone of 21st to 23rd May 1843. Track X. on Chart No. III., in which Captain **Corney**, of the ship *Lord Lyndoch*, when close to the centre of the Cyclone, and but shortly before the shift of wind says—

"The strongest gusts were about 1 P. M., when there were intermitting severe gusts, *accompanied by great and terrible heat—and there were alternate gusts of heat and cold after the hurricane veered to S. W.*"

Having no thermometric data, we cannot say what the extent of these variations of temperature were, but they are very remarkable as occurring at this time, and while the fury of the Cyclone was from seaward, the N.E. Nevertheless as the vessel was close in with the land some uncertainty exists as to the origin of this heated air, but if it came originally from the land, it must have been carried up and then forced down again without alteration or mixing! which we can barely allow.

365. Captain **Millar**, whose able management of the *Lady Clifford*, I have alluded to at p. 123, says in a letter to Captain **Biden**, with his log of the Madras storm of 1836—in the ship *William Wilson*,

"In the storm under notice there was an extraordinary change took place suddenly in the temperature of the air, but I regret that I cannot state if a corresponding change took place in the Thermometer, as I had not looked at that instrument, until directed to it by my own feelings, and the complaint of cold from all my crew."

366. Captain **Rundle** also, whose log I have quoted so often, says incidentally:—"The rain water exceedingly cold, the sea water very warm, much more so than usually;" and in another place "fresh gale with furious squalls and rain as cold as ice." This vessel was in 5° or 6° South latitude only. The *William Wilson* was in from 11° to 12° North only, so that these cold and hot blasts and rains become matter of curious speculation as to their origin.

367. **Points of Enquiry, and Directions for Observers.** I have so often alluded in the course of this work to the many matters we have yet to enquire into, that at first it may seem a repetition to go over this again; but it is always advantageous to have such matters brought closer together under distinct heads, and there may be some which I have at heart, but have not been able to suggest.

Let us take the enquiries in their natural order:—Before; during; and after a Cyclone.

368. Before a Cyclone *a*. The atmospheric signs of all kinds, celestial, terrestrial (if in port) and those of the ocean, as in our table at p. 226, being sun, moon, stars, sky, clouds, light, air, wind, lightning, thunder, noises, effects on animals, &c. Appearances of the stars should be carefully noticed, distinguishing between the fixed stars and planets, and between those near the zenith and at the horizon.

b. The signs considered by natives or European inhabitants of different places as announcing an approaching Cyclone, and especially those connected with volcanoes and earthquakes, and their subsequent relations to the Cyclone when in action, if any. Pilots and fishermen are often very well informed on these matters.

c. State of the barometer and simpiesometer, both on shore and on board ships if in port; for the one might, for instance, oscillate and the other not.

d. States of all other meteorological instruments, such as hygrometers and the like; of any sorts attainable.

e. Exact observations as to the state of the clouds, &c., above; or that of the weather in elevated spots, so as to elucidate as much as possible the question of whether the Cyclone is formed at the surface of the earth or in the higher regions of the atmosphere.

f. The bearings and angular altitudes of all banks of clouds, and distances of them, as nearly as can be measured by the directions given by **Kaemtz**, (p. 216), the time of the experiments being accurately noted. The bearings of the extremes and centre should be taken. If bands of light or colours are well defined, the angles subtended by these should be measured by a quadrant or sextant.

g. In the neighbourhood of volcanoes, their peculiar actions should be noted, and the opinions of the residents enquired into, as also where volcanic lakes, and the like, are known to become agitated or phosphorescent. When volcanoes are near the sea, it is by no means unlikely that they may show some forewarning indications.

n. The state of the surfs on coasts, peculiar swells arising from the sea, its phosphorescence, the appearances or flights of peculiar birds, or even the peculiarities known to fishermen of the habits of

fish should not be neglected. At first sight many of these things seem mere fancies or local superstitions; but if we found on opposite sides of the globe, for instance, that on the approach of a Cyclone, certain fish, abundant at other times, are not to be caught for three or four days before its outbreak; or that certain others are seen to be much agitated and to come constantly to the surface, we might fairly say, that this was a fact derived from observation, and if verified by competent observers, it might be a clue to further knowledge.

i. Observers on shore might render great service by carefully pursuing any *one* single branch of research or observation only, and of these some do not even require instruments, or very simple ones. As an instance, I may cite a series of careful cloud, or (to use the Greek word, which Mr. **Espy** has usefully adopted) NEPHELOGICAL observations, which might be of high importance, both as shewing for a long period, what the various currents above and below are, and what are the peculiar appearances which forewarn of the approach of Cyclones at that place.

j. The various names given by the Natives or European residents to various kinds of gales; as an instance see the note at p. 45, and in the next section, the remarks on the names Hurricane and Tyfoon.

k. Great attention, both at sea and on shore should be paid to the choice of the *words* used to describe the different phœnomena of Cyclones. For example the words "veered" and "shifted" are often carelessly used for each other, yet they express, the one, a gradual, and the other a sudden change of wind.

l. The intervals of *time* between the various changes in the storm or the states of the instruments should also be marked. As thus: "The wind veered between 4 A. M. and half p. 6 A. M. from North to W.b.S." or "The barometer sunk from 8h. 30′ to 10h. 45′ A. M. from 29.05 to 28.70 as per register."

m. Whirlwinds and water-spouts, and peculiar veerings of winds with them and alternations of calms, and puffs, and flaws. The appearances of whirlwinds and water-spouts, and their manner of turning, whether ↻ or ↺ should be noted with all details, particularly if occurring at night.

n. Rising and falling of wind, and if any moaning or distant roaring noises are heard before or after the Cyclone, and if these noises are certainly in the atmosphere?

369. DURING A CYCLONE. *a.* Atmospheric states and changes as often as can be noted, and particularly at the changes of wind, and at the calm centre, if this should unfortunately reach the ship.

b. State of the barometers, simpiesometers and thermometers, as often as possible, their oscillations, and if (which should be observed in the dark) any flashes of light, can be *certainly* distinguished in the vacuum of the tube, and if these are constant for a time, or by fits, and if connected in any way with the oscillations.

c. The same at the shifts or calm.

d. Lightning and thunder; and particularly remarkable flashes at the shifts.

e. Phosphoric light of the sea.

f. Temperature of the rain; if colder or warmer than the sea, form and size of hailstones if any; relation of the fall of hail to the lightning and state of the barometer.

g. Whirlwinds or water-spouts occurring in the Cyclone to be carefully noted, as to their appearances, whirlings, tracks, size, &c.

h. Circles of light or clear sky overhead in the midst of the Cyclone, to be estimated or measured as to how many degrees in diameter; stars, moon or sun, if seen at any time in the Cyclone, to be also noticed if of peculiar brilliancy or colours.

i. State of the sea, as to regularity, rising, falling, breaking, &c., particularly at the centre.

j. Veerings or oscillations of the wind, and if possible, the exact intervals of time in which they occur should be measured. Thus if we knew, that the wind veered backwards and forwards 6 points about every 15 minutes, we might, with the drift, calculate what the amount of incurving was.

k. Moderating of the wind for an hour or two or more, after the gale or Cyclone has appeared to commence, and the state of the barometer, simpiesometer, and sky at this time.

l. An exact account should be, if possible, kept of a vessel's coming up and falling off, and the log should be hove if possible, to

ascertain with the utmost care,* the direction and rate of the ship's drift if lying to; so as to be enabled after the Cyclone to calculate with precision what may be due to the storm-wave and storm-currents.

m. Blasts of hot or cold air. Extraordinary light or darkness.

370. AT THE CLOSE OF A CYCLONE. *a.* Appearances of the clouds, when going off. If forming banks to be noted and measured, as at the approach of the Cyclone.

b. Gradual rising of the clouds at the horizon or zenith to be noticed if it occurs.

c. Barometer and Simpiesometer, rate of rise to be as carefully noted as during the Cyclone; and how long the oscillation continues after the passage of the centre.

d. Any effects of the Cyclone on the ship's compasses, or on the respiration, or on animals on board, &c., to be carefully noted.

e. On shore any accounts of inundations, and if by sudden sea waves or gradual rising. Old and foreign accounts of these also to be collected if obtainable. Directions for preserving records of the state of the weather in the British Colonies have been issued some years ago, but it is not known what these have produced. The importance of obtaining the observations of foreign settlements, is therein also alluded to.

371. **Directions for Observers.** We have four classes of observers who may be useful to us. 1, Those on shore, landsmen or sailors. 2, Sailors in harbour, where they have much more leisure and advantage. And 3, Sailors at sea. 4, Surgeons and Passengers. As it may, however, be useful for all to know what the others might observe, if they pleased (for they will thus know how to question them, or what to ask for in the way of copies of papers, &c.) I set down the whole together, and each class will easily distinguish what belongs to them.

372. I commence with pointing out what may be done with the observations when made or obtained from others; for I know that many are deterred from, or rendered indolent-minded about such

* By a leeway-circle on the taffrail, if this can be managed. I mention every thing, though I well know that in merchantmen all hands are fully employed; but in Men of War much may be accomplished by a little zeal.

matters, by the feeling of "*What is the use of all this trouble in making notes? I do not know where and how to send them to any one who will make use of them.*" I trust that none will have read this book without being convinced that, speaking for my brother Storm-meteorologists,* as well as myself, we shall always be glad to turn every scrap of information to account, and to forward to each other such as may assist our common research in those quarters of the globe where we may be situated; and those who have read all the works on the subject, can I hope also testify how usefully and faithfully every line yet obtained *has* been brought to account for the great family of mankind.

373. For myself, I shall be glad to receive notes, memoranda, or extracts from books, from any part of the world on storms, or matters relative to them, in any language; as detailed or brief, and as plain or as scientific as may be, and if these are addressed as below, they will always reach me free of Indian postage.

Storm Report Service.

The Secretary to the Government of India,
Home Department.

Mr. H. Piddington,
Calcutta.

Packets or letters forwarded to the publishers of this work, will also reach me.

374. It will be seen from the foregoing pages that, independent of the particular points of enquiry, which I have specified in the first part of this section, there are wide blanks to fill up in the chapter on the tracks of the Cyclones alone; and that we ought gradually to be able to produce charts for every separate tract of sea, like the four which we have now given; and that this can only be done

* W. C. **Redfield**, Esq., New York. H. E. Lt. Col. **Reid**, Governor of Barbadoes. Dr. A. **Thom**, H. M. 86th Regiment, Poonah, Bombay.

by the workmen being furnished with materials; and a single experiment with a storm card will shew them, that if a hurricane moved, (for instance across the Atlantic or Bay of Bengal,) from West to East instead of the contrary way, which we now *know* they do, all the changes of winds and rules for management would be different. Hence the great utility, tedious and sometimes almost repulsive as the labour is, of collecting the data and investigating every separate storm till, as in all other branches of the physical sciences, we are able to say with comparative or absolute certainty, what is the LAW by which their tracks are governed, since we know that of their rotations.

375. As I have before said, for these investigations we must have data, and these data are log-books, journals, memoranda, newspaper notices, and the like; and the more clearly to explain what we require, I set down here in separate paragraphs, what occurs to me; premising always, that *the more details, the better.*

1. We require all the accounts, registers, and notices, logs, journals, memoranda, and even *references* to books, (in any language,*) which can be obtained.

2. These may be new or old, for the phœnomena of the storm of yesterday may be corroborated by those of a hurricane a hundred years ago.

3. They may be plain common-sense notes or narratives, or as scientific as they can be made; but the plain common-sense accounts are often *quite as valuable* as the scientific descriptions, and it is a great mistake, and one I fear, which has deprived us of much good material, to suppose that we *must* have scientific data, because the research requires the aid of science to develop the laws to which they lead.

4. A mere note of the times of commencement, violence of the wind, from what quarter, how changing, how ending, and the position of the observer on shore, or the latitudes and longitudes at sea,

* Many valuable hints are to be found in the old navigators, English as well as foreign, but few or none of their works are obtainable in India.

with the run, &c. are all that are strictly required. If the barometer, thermometer, simpiesometer, and all other points noticed are added, so much the better.

5. The place of the observer at noon each day before, during, and after the storm, should be carefully given at sea; even from mere estimation, if nothing better can be obtained; because no one can, from a log, estimate a vessel's drift in heavy weather so well as those on board of her. And the exact positions before and after the storm are always important.

6. On shore, the latitude and longitude of the place, or its distance and bearing from the nearest well known station or city, should be given; and some notions of its position as to mountains, hills, rivers, vallies, &c. will be always useful.

7. Mariners may very usefully employ their own leisure hours, or the leisure hours of any boy on board who can write, during a passage, by copying from their *old* log-books, no matter *how* old, the logs of any old storms, or the logs which shew a ship to have been *near* the place of any known storm; and especially to copy the log of any storm they may have had on the actual voyage, so that it may be ready to send on their arrival in port. I have reason to believe, that many Commanders are willing, and even desirous of aiding us, but when they come into port, they are hurried and anxious, do not like to send their log-book out of the ship, and finally leave without carrying their good intentions into effect. Much valuable information is thus lost. As to the old logs, *I have* a great deal of scattered information thus collected, which might become far more valuable, with the addition of a few more corroborations.

8. Another very mistaken notion is, that some are apt to fancy that their particular log, or note, or memorandum on shore is "*of no great consequence.*" This is a very mischievous notion, and I entreat those who may entertain it to consider first, that it is impossible to say beforehand, in any research of this kind, *what* is, and what is not, important; and next that twenty proofs are always better than ten.

9. Some also, I fear, who may not have looked into the details, excuse themselves by saying they do not believe in the truth of the

Law of Storms. There is no harm in this opinion—if it does not cost the dismasting or loss of a ship—and I am old enough to have heard Barometers, Lunars and Chronometers sneered at, as "new-fangled notions;" but I think I do not exaggerate when I say, that in the writings already published on the subject, there is to be found, for every impartial mind, abundant and almost mathematical proof of its correctness. And if these researches are not useful, it certainly can do no harm to publish all the facts relative to storms for scientific men to make some *other* use of.

10. I fear also, that some Shipmasters, who may not have enjoyed a good education in early life, may feel a little embarrassed and unwilling to submit their log-books or extracts to the eye of a stranger. I can only assure such, that I have had many log-books, in which great deficiencies were observable, but have never, and should on no account, think of ridiculing, or even of criticising them beyond what is strictly necessary to establish the truth of a question.

11. Copies of public documents, such as reports, registers, and the like should be enquired for.

12. Details relating to inundations and the manner and time at which they occur should be collected, and the *gradual* risings of rivers carefully noted, apart from the *sudden* ones, or sudden waves rolling in from the ocean or great lakes.

13. Cases of the compasses being affected after a Cyclone in which the thunder and lightning, or the lightning alone, was very severe.

376. *Persons residing on shore should,*——

1. Set up a vane or weathercock if there are none in sight, and if they are not old seamen enough accurately to estimate the point from which the wind blows.

2. They should also, from various parts of their dwelling take North and South and East and West marks *in fine weather,* at not too great a distance, such as trees, chimneys, &c. In a storm they will find these of essential service in estimating the course of the wind, and that of the clouds.

3. If furnished with instruments the registry of all of them before, during, and after a storm, will of course be most acceptable; and if compared with standards so much the better, but a plain

common-sense account of all the phœnomena of a storm; or of the weather when one is passing near, the driving of the clouds, the *times* of the changes or veerings of the wind, calm interval, &c. &c. are all that are required in most cases, and will always be eminently useful.

4. The collection of reports from other parts is also a most useful assistance to us; even if mere native ones, they are better than none.

5. Accounts of tornados or wind-spouts, dust-whirlwinds, &c. their tracks, the direction in which they turn, whether *with, or against* the *hands of a watch,* and notes of their formation, progress, ravages and disappearance, are all of great interest and utility.

6. In observing the oscillations of the barometer so frequently alluded to, we should be careful as to the observations made in the height of a Cyclone, that the room or cabin be not too close; for it might happen that the heavy gusts might force a volume of air into a closed apartment which would momentarily force up the mercury by its pressure; care should be taken on this account to have the instruments placed so as to obviate this objection, as by opening a window or door to leeward, or the like. Of course this does not apply to the oscillations at the approach of the Cyclones.

377. **Miscellanea.** The Log-Book. On the label of a ship's log-book sent to me, and which was, it appeared, printed and sold by **Clark** and Co., 72, Gracechurch Street, London, I observed below the usual title and form for entering the ship's name, voyage, &c., the following very proper caution—

"N. B.—On the accuracy of a log-book depends the recovery of the owner's and shipper's property, in the event of loss. No erasures or obliterations ought to be allowed, but every incident recorded in a clear and explicit manner, and, on no account, should the log-book of a former voyage be permitted to remain in the ship, but should be deposited for reference with the owner or broker."*

* Sailors would demur greatly to this: many capital runs and safe passages through difficult straits, good and essential recognizances of headlands, &c., are made with the help of old logs. No ship should be allowed to go the same voyage twice, without having a copy of her old log-book, which may often serve to correct an erroneous, or supply a deficient, chart.

378. I have elsewhere said (XI. Memoir, Journal Asiatic Society, Vol. XIV.) that—

"It has often struck me to remark on the absurd practice of keeping a ship's log-book without entering the longitude. It is quite possible that a case might arise in which, at least ignorance of his true position, if not wilful destruction of his vessel might be alleged, if not proved, in a court of law against the master of a ship through this omission; and his insurance thereby become vitiated or his character destroyed, though really a good navigator, in case of an accident. The private log, or "lunar and chronometer book" of a Captain, would barely be held as a legitimate document when the book which *should* contain the vessel's place at noon is a blank."

379. But passing over all this, none will question that a well kept log is as high a testimony of a commander's ability, as a well kept set of books are to the commercial talent of the merchant for whom he sails. But when we see (as I have seen scores, if not hundreds) of log-books, even of voyages to India, in which, if the log is hove it is not registered every hour, or it is registered by mere guess; which by the way is almost a fraud; or the barbarous and careless form of the coaster's logs (marking every two hours only) is adopted; leeway, variation, barometer and simpiesometer apparently not thought of,—though the opening of a cask of beef or peas is carefully set down,—while the stock of water on board, even with troops, often seems a mystery! and in fine every thing, to all appearance, is left depending on the latitude and *the* (one) chronometer; and this even on the approach to land. When we see all this, I say, we must regret to avow that in this respect the French are far before us; for not only are their merchant ship's logs properly filled up with every thing that a good log-book should contain, but moreover, in most of them,* the log of each watch has the signature or initials of the officers by whom it is written; so that it thus becomes what Messrs. **Clark** and Co. properly recommend that it should be.†

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* I speak both of original logs and of copies. In these last the signatures alluded to are usually omitted.

† Nautical Booksellers would much aid the advancement of our science, and furnish their customers with useful hints, if they were to adopt Messrs. **Clark's** useful plan, and their N. B., might run something as follows:—

380. MODERATING OF THE WIND AT THE COMMENCEMENT OF CYCLONES. The following note from the Horn-Book of Storms for the Indian and China Seas, describes this remarkable peculiarity; of which I have again and again met with notices in numerous logs, and in many instances I have remarked that commanders have been deceived by it. The rule is simple, "*Make no sail till your Barometer rises.*"

"In the hurricanes of the Bay of Bengal and China Seas, it seems not an uncommon circumstance, that in a few hours after their commencement, there is a lull for an hour or two, or more; after which it comes on to blow harder than before from the same quarter. I observe that this is also noted in the hurricanes off the Isle of France and in the West Indies. This treacherous peculiarity might, without attention to the barometer, deceive those unaccustomed to our tempests. I have not met with an instance of these lulls occuring more than once at the commencement of a storm. I do not allude here to the lull or calm which precedes the shift of wind, which occurs when the centre of a storm is passing over a ship or place, but to a sort *of promise of fine weather* which occurs at the beginning of a *hurricane*."

381. There is also a kind of treacherous fair weather interval when no *blowing* weather has occurred, and the only indications have been dark lowering clouds and a fall in the barometer. It is perfectly well described in the following note appended by Captain **Biden**, to the log of the ship *Princess Charlotte of Wales* in her Cyclone of March 1828 in the Southern Indian ocean. Track *k.* on Chart II.

"Previous to the gale, the weather had been unusually close, Ther. 82°, and for 48 hours the clouds were dark and fixed, with an appearance indicative of heavy rain, Barometer steady. The approaching change of the moon in its Peri-

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N. B.—On the accuracy of a log-book depends the recovery of the owner's and shipper's property in the event of loss, and the good names of the Captain and Officers. The ship's latitude and longitude should be carefully noted at every noon by observation and account, chronometers and lunars, and leeway, variation, deviation, barometer and simpiesometer duly entered. All changes of wind and weather, and peculiar appearances on the approach of bad weather should be registered. Erasures and obliterations should be avoided, and alterations certified by a note in the margin. A duplicate log should be kept and daily signed, and on the ship's return to port, all bad weather or extraordinary phœnomena should be reported.

gee caused an anxious attention to the Barometer, which gave the first warning at 11 A. M., on the 14th, falling gradually until 8 P. M., when it sunk with more rapidity then I ever witnessed, the sure presage of a storm! Without this excellent and almost infallible instrument, the most experienced seaman might have been lulled by the sudden change at 2 A. M., stars bright, clouds fixed, and every appearance of settled weather. The Barometer fell from 29.27 at midnight to 29.08, the certain precursor of a hurricane. The heavy rain had so tired and exhausted our men, that at midnight I relieved the watch in hopes of a few hours daylight to get the top-gallant masts upon deck; we had just handed the main top-sail and rounded to on the larboard tack with scarce a breath of wind, when the gale came on at W.S.W., and at 4, it blew a perfect hurricane."

382. While this page is going to Press, I see in the *Singapore Free Press*, an instance in which the brig *Guess*, with a falling Barometer at 29.50., and wind N.N.W. in the China Sea, *in the month of August* 1847, (the height of the S.W. monsoon) was seduced by an interval of moderate weather into making sail so far as to let out reefs and set top-gallant sails at 3 P. M.; having double reefed at 2 P. M. By 6 it was a strong gale, and by midnight a tyfoon (Cyclone) had commenced.

383. ETYMOLOGY (DERIVATION) OF THE WORDS HURRICANE AND TYFOON. This word Hurricane seems originally to have been a Carib or Indian one, for in the *Relacion summaria de la Historia Natural de las Indias, &c. &c.*, addressed to the Emperor Charles V. by Captain **Fernando de Oviedo**, speaking of the superstitions of the Indians (Caribs) of Tierra Firme, probably about Yucatan, the author says—

"So also when the Devil wishes to terrify them (the Indians) he promises them the *Huracan*, which means Tempest. This he raises so powerfully that it overturns houses and tears up many and very large trees; and I have seen in thick forests, and those of very large trees for the space of half a league, and continuing for a quarter of a league in length the forest quite overthrown, and all the trees, large and small, torn up by the roots; the roots of many being uppermost, and the whole so fearful to see, that it doubtless appeared to be the Devil's work, and could not be looked on without terror."*

* I give here the original old Spanish. "Asimismo, quando el Demonio los quiere espantar, prometeles el *Huracan*, que quiere decir, Tempestad: la qual hace tan grande, que derriba Casas; i arranca muchos, i mui grandes Arbo-

The author here exactly describes the passage of a tornado in a thick forest, and by the explanation he gives of the word *Huracan*, we see that it was an Indian one. The Dictionary of the Spanish Academy does not give the derivations of words. In the extract from **Ramusio** at p. 260, we find also that the same author gives the same word as the Haytian name for Cyclones.

384. TYFOON. This word is undoubtedly Chinese, and by no means derived from the Greek "Typhon," as has been supposed. Dr. **Morrison**, in his Notices concerning China and the Port of Canton, says that—

"At Hainam and the Peninsula opposite (to the North of it), they have temples dedicated to the Tyfoon, the god (goddess ?) of which they call *keu woo* "the tyfoon mother," in allusion to its producing a gale from every point of the compass, and this mother-gale with her numerous offspring or a union of gales from the four quarters of heaven makes conjointly a *taefung* or tyfoon."

In a work called "*Kw'an Tung Sin yu*" the tyfoon is called either *kow-fung* or *fung-kow*. A severe one is called *teĕ hwuy* or *Teŏ keu*, an iron whirlwind.*

They have also separate names for whirlwinds, which I am informed are called "*Yung-kok-foong*" and "*Suing-foong*."

385. These names are not questions of mere curiosity, for apart from the use to the sailor of knowing the native terms for every thing relative to his profession in every country, the mere fact of such special names existing for various kinds of gales, shews at once that there are certain well-known and recognised phœnomena, or effects, distinguishing the Cyclones. Thus in one of the South Sea Islands, they are called "the wind that breaks the bannana-trees," and I have mentioned at p. 45, the names *bagyo* and *sigua* as those given by the natives of

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les ; i yo he visto en montes mui espesos, i de grandisimos Arboles, en espacio de media legua, i de vu quarto de legua continuado, estar todo el monte trastornado, i derribados todos los Arboles, chicos i grandes, i las raices de muchos de ellos para arriba, i tan espantoso cosa de vèr, que sin duda parecia cosa del Diablo, i no de poderse mirar sin mucho espanto."

* Captain **Doutty**, of the *Runnimede*, in his log exactly uses the same metaphor ! likening the wind ripping up the front of the poop to "a metallic body."

the Philippines to Cyclones and monsoon gales. Ships that visit the Marianas, Carolinas and other groupes, islands, and coasts of the Pacific, from the Kuriles to New Zealand and Chiloe, may collect much information by attending to the details of natives and residents relative to their different classes of storms: as for instance, we might learn from the pearl fishers and smugglers of California, and from the coast Indians, South of Valparaiso, what the usual changes of winds are in their storms, and thence deduce the tracks.

386. APPEARANCE OF THE STARS. I omitted to remark upon the only two instances, in which the appearance of the stars has been noted in our table, as indicating the approach of a Cyclone. Yet, as we shall presently see, it is probable that these bodies may often afford to the attentive observer, a warning, in corroboration at least of other signs. Capt. **Langford,** in our table, p. 227, notes only "a burr" about them, which must be common in all hazy states of the atmosphere; but Capt. **Rundle** mentions a "dancing sickly appearance" of them.* In commenting upon this in the Memoir in which his log is published, I have remarked that it may be owing to wreaths of vapour, and the intervals between them; and I have also adverted to the tremors of objects seen through telescopes in the mornings, as occasioned by the rarefaction of different strata of it, an appearance and cause usually well known to intelligent seamen. Meteorologists are also well agreed as to the usual causes of the scintillation of the stars, which I take to be the "dancing" alluded to; only that it was so excessive that it gave the idea of motion rather than mere scintillation (sparkling); but they add also, what we should in future note; that apparent changes of *colour* as well as of brightness and place occur in the stars, especially at the times when they are most scintillating; or the changes of colour may occur with the planets also, though they rarely sparkle. Thus a blue or red star may change to the opposite colours, or become remarkably silvery and white for a short time, and then return back to its usual colour. All these are matters to be noted

* Which was carefully observed; for the log, says, "I thought at first my eyes deceived me, but my mates observed the same; I suppose occasioned by some dense vapour?"

and carefully registered; they may be the first indices of the actions going on in the atmospheric strata above, and by their frequency and constancy in certain circumstances may be far more useful as premonitory signs than we at present suppose.

387. SURGEONS AND PASSENGERS. Having said so much to the sailors (more indeed, perhaps, than will be acceptable to some of them?) I must address a word to another class of persons often found on board of ships, and who may materially assist us in many things, and that is to THE DOCTORS AND THE PASSENGERS.

These gentlemen may often usefully get over some of the *ennui*, of which they all, for the most part, complain, by careful registry of the meteorological phœnomena, and especially at the approach of gloomy or bad weather. If they honour this book with a perusal, they will see that there are very many points which *can* only be attended to in bad weather on board of Men-of-War, or of first rate East Indiamen, and yet which might throw a great light upon our researches; and I hope that every educated man will feel with me how serious a duty it is, morally and politically considered, which their country and mankind can claim from them in these cases. If they merely note any one point, such as the course and appearance of the clouds, and the exact direction of the wind, or the electrical appearances, they may greatly aid future research, and they will find in what has been said (from p. 267,) an ample choice of observations to make.

388. WORKS ON STORMS. The following is a nearly correct list of all the works and papers on the subject of Storms which have preceded the present book.

1. **Capper** on Winds and Monsoons, London 1801.
2. Papers by W. C. **Redfield,** Esq. of New York; in the American Journal of Science and (English) Nautical Magazine from 1831 to 1846.
3. Papers by Lieut. **Evans,** R. N. Nautical Magazine, and **Purdy's** Atlantic Directory, 1838 to 1839.
4. Professor **H. Dove** of Berlin; several papers.
5. Colonel **Reid;** Attempt to develope the Law of Storms, first Edition 1838, second in 1841.

——————— Disquisition read to the British Association, August 1838.

6. Dr. **Brewster;** in Edinburgh Review for January 1839, Vol. 68.
7. Captain **Basil Hall;** in Foreign Quarterly Review for April 1839?

8. **H. Piddington;** Fourteen Memoirs on various Storms, Journal of the Asiatic Society, Vol. VIII. 1839 to Vol. XIV. 1845.*
—— Notes on the Law of Storms for the use of the Expedition to China, two Editions.
—— The Horn-Book of Storms for the Indian and China Seas. Three Editions, 1844 to 1847.
9. Professor **J. P. Espy;** The Philosophy of Storms, Boston and London 1841.
10. North American Review, No. 123, April 1844.
11. **Alex. Thom,** M. D., H. M. 86th Foot. Inquiry into the nature and course of Storms, London 1845.
12. Professor **Loomis.** On the American Storm of December 1836. American Philosophical Transactions. New Series, Vol. VII.
13. Calcutta Review for October 1847.

389. TORNADO-CYCLONES. These appear to exist also between the Azores and the Chops of the Channel, and within the Channel, in considerable force. In April 1845, the *Monarch,* Captain **Walker,** homeward bound from India, was at 10 A. M., on the 22nd April 1845, with barometer at 29.70 under double reefs. At 2 P. M., breeze freshened from the S.W. with every appearance of bad weather. Barometer at 29.50 and all preparations were made, ship steering to the E.N.E. 7 P. M. Bar. 29.30, blowing very hard, high sea and atmosphere very threatening. At 8 P. M. Bar. 28.95, furled every thing but storm mizen try-sail. At 8-30, wind suddenly lulled to a dead calm which lasted a quarter of an hour, ship not steering, and the sea striking the counter in an awful way shaking her fore and aft,† the appearance of the weather stormy in the extreme, with rain *and lightning.* At 9 P. M. instantaneously from a dead calm, it blew a most terrific gale from the North with rain and hail. Fortunately every sail was firmly secured, or Capt. **Walker** was convinced the ship would have been dismasted, this continued for one hour, and settled into a strong gale which lasted until sunrise, the wind having gradually veered to N.W. and the barometer steadily rising.

The following also, which is reprinted from Mr. **Redfield's** Memoir on the Cuba Hurricane of October 1844, p. 68, is a recent

* For a detailed list, see p. 1.

† The *Monarch* is a first rate Indian passenger ship of 1400 tons, and was then on her first voyage.

instance of a tornado-like Cyclone in the Channel! It originally appeared in the Calcutta papers.

"Oct. 7th A. M. wind N.N.W. moderate; noon, Lat. 49° 47′, Lon. 4° 23′ W. Bar. 30 in; P. M. wind S.S.W., increasing. Oct. 8th, noon, Lat. 49° 20′, Lon. 7° Bar. 29° 50′, the whole 24 hours very unsettled weather and barometer falling; wind S.W.; unsteady, and increasing. Oct. 9th, wind had veered to N N.W., coming in hard gusts with sudden intermissions, and barometer had fallen to 28.60; sent down small spars, double-reefed, &c. at 8 A. M. Bar. 28.50, and weather clearing up to the eastward, *thought of making sail, notwithstanding the low state of the barometer.** Saw a schooner close to us with a good spread of canvas. But the wind suddenly flew out from N.E. and back to E.S.E., then E. and we observed the water blown up like clouds of dust, and the sea in frightful commotion. This took place at 1-30 P. M.; the barometer having been 28.44 at noon, 28.35 at 0-30 P. M., and lowest at 1 P. M. 28.12. It was now (1-30 P. M.) at 28.14, and before the canvas could be got in, the hurricane had struck the ship from the northward with extreme violence, driving her forecastle under; at 2 P. M., Bar. 28.40, at 3 P. M. with great difficulty brought the ship to on the starboard tack; 3 P. M. Bar. 28.60 at 5 P. M. hurricane less violent and settled into a heavy gale, veering to N.W. and W.N.W.; at 8 P. M. severe gale, with sleet, hail, rain and vivid lightning; at midnight Bar. 29.99, gale blowing with unabated violence. The schooner which was close to us disappeared suddenly, and there is little doubt that she foundered. Oct. 10th, heavy gale from N.N.W. with a high sea; noon, Lat. 48° 51′, Lon. 8° 4′ W., Bar. 29.40, midnight, no alteration."

390. THUNDER AND LIGHTNING. In the Mauritius Cyclones of 1786 and 1789, as described by **M. Peron,** he says, of the first of them, that thunder and lightning were "nearly incessant throughout the whole of this terrible storm," and that a meteor was seen resembling a globe of fire, following the direction of the wind, then from the N.W., and which disappeared behind the mountains of Moka. It was considerably elevated in the atmosphere, and seemed nearly half the size of the moon. In the second of these Cyclones thunder and lightning are not mentioned, but it was in this that the remarkable phœnomena of flashes of light in the vacuum of the Barometer tube, (see p. 186,) were seen. This again would seem to indicate, that there are two kinds of Cyclones. That of Barbadoes also, as described in Col. **Reid's** work, differs in this

* Another instance of the temporary clearing up just described at p. 278.

respect from the usual accounts. In the Chinese work just alluded to, as quoted by Dr. **Morrison,** he notes, that "they say, if it thunders, the gale (Tyfoon) breaks up."

391. In open Roadsteads, pp. 120 to 123, I have alluded, in the notes at p. 120, *Note,* and p. 122, to the case of Madras Roads. By the following extract from an official report, I am enabled to corroborate exactly the view I have there taken of the proper course to be steered when running to sea. Captain **A. Stuart,** commanding the ship *Baboo,* says—

"With regard to casual storms or other incidents, I can say but little; with exception of the gale of the 21st May at Madras, when in company, and after the *General Kydd,* I put to sea. We had two very severe nights of it, but fortunately I got well to the Southward of Madras, and returned to my anchorage on the 24th.

"During the gale the wind with us was most severe from North and N.W. at the latter point it blew with fearful violence, then moderated and veered round to S.W. in the afternoon of the 22d; with which I made sail, being then distant from Madras 118 miles, bearing N.N.W., and arrived without any damage."

The *General Kydd* is the ship alluded to in my note, and she ran out so as directly to meet with the centre. The *Baboo* "fortunately got well to the Southward of Madras," i. e., steered far enough to the South to avoid the centre, though in passing the S.W. quadrant of it, she had the gale excessively violent, being then nearest to, and close upon the centre. Some of the other vessels which slipped from the roads also escaped the centre, but the unfortunate barque *Braemar* being, like the *General Kydd,* too far to the North, was laid on her beam ends, and only righted by cutting away her masts, the wreck of which carrying away her rudder she drifted in an unmanageable state on shore, and was wrecked near False Point Divy.

392. Incurving of the Winds. In the *Thomas Grenville's* Cyclone, mentioned at p. 166, it is noted just after the passage of the centre, that the wind was "blowing in awful gusts from East to N.N.E."

In the *Northumberland's* log, in p. 165, the wind close to the centre is noted as veering from South to East, the vessel being kept as much as possible before it.

A still more recent instance is the case of the ship *Caledonia,* from China to Bombay, which ship 'chased,' overtook, and ran

into a small Cyclone No. XIV. on Chart No. III. (see Jour. As. Soc. Vol. XIV.) till she reached the calm centre, and for three hours before she did so her log states, "Heavy gale, *wind shifting from South to S.E.*" and "increasing gale, *wind continually shifting from South to S.E. and back again;*" and these are exactly the alternations which a ship running into the vortex of a Cyclone in the Northern hemisphere, on its Eastern side, *should* have from incurving winds.

393. Stationary Storms. I have omitted to notice at p. 59, under this head, the Cyclone of September 1838, at the Bahamas, and along the coast of America, in which H. M. S. *Thunder* and *Lark*, were in great peril; as noted by Colonel **Reid**, p. 433, and in the Nautical Magazine for 1839. Colonel **Reid** is of opinion that, over the Bahamas, and for a time at least, this was a hurricane resembling that of the *Albion* in 1809, and floating about in no fixed course. He remarks also that this occurred about the recurving point of the West India Cyclones.

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"This Storme continued not onely a day or two with one winde but seven or eight dayes continually, *the winde turninge round about in all places of the compasse at the least twice or thrice during that time,** and all alike with a continuall storme and tempest most terrible to behold, even to vs that were on shore, much more then to such as were at sea."

394. Tracks of Cyclones. On the West coast of Australia, off Rottnest Island, the French discovery ship *Le Geographe*, appears by **M. Peron's** report, as translated by **Pinkerton**, Vol. XI., to

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This shift, which is of course the average one only, would indicate a track *from* the S.W. towards the N.E., or one exactly opposite to that described at p. 48.

396. **Barometer signals to ships.** The Captain is on shore and the Barometer on board? The Mate is embarrassed with cargo, unstowed in the hold, loose cargo upon deck and between decks, and cargo-boats alongside? or he is a young officer, who is afraid of being thought over-cautious or over weather-wise? or is an old one, but not upon the best terms with his Captain? or the Captain is what the French expressively call a *vieux loup-de-mer,* and might growl at time being lost, or boats being returned to allow preparations to be made for expected bad weather without his orders?—or, in short, a hundred circumstances, well known to all merchant sailors, may occur to place a very deserving officer in the unfortunate situation of being blamed for not having his ship ready

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for bad weather; either to slip and go to sea, or to ride it out; and serious loss and damage to valuable property, if not frightful loss of life have been, and still will be, the results; for want of a right understanding, or from an over-confidence in the security of the port. We cannot provide against all these contingencies in detail, but it is a duty to point out to Governments, Chambers of Commerce, and the Mercantile Community, the advantage to all parties derivable from a properly organised system of signals, indicating the approach of bad weather, and the state of the Barometer, as declared by a standard instrument, and by the opinion of the authorities of the port; who are in all cases supposed to be competent judges, and acting from disinterested motives. Every port must have its own particular signals, adapted to its own localities, but the following as relating to this subject in the Western Hemisphere may be worth perusal and imitation, in ports subject to Cyclones.*

397. **Barometer Signals at Barbadoes, by H. E., Col. Reid, Governor of that Island.**

The following Memoranda are published by order of His Excellency the Governor.

JAMES WALKER,
Colonial Secretary.

MEMORANDA RELATIVE TO THE HURRICANE SEASON AT BARBADOES. A barometer will be kept and registered at the principal Police Station at Bridge-town; and notice will be given to the Captain of the Port when it falls. On the Captain of the Port will rest the responsibility of causing Signals to be hoisted, that the barometer indicates bad weather.

One ball at the mast head of the signal posts, is to signify that the barometer is falling, and should be carefully watched.

If the barometer continues to fall, and the weather appears threatening, a second ball will be hoisted at the mast head.

As the indications of the weather become alarming, these two balls will be gradually lowered, until they are only half mast high.

As soon as the barometer begins to rise again, the two balls will begin to be slowly rehoisted, so as to be again at the mast head, when the barometer shall have risen one tenth of an inch.

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* At Madras they have a very good code of signals for warning ships to be ready to put to sea, but I do not know if they have extended this to shewing the state of the Barometer also, which, as just shewn, is so useful as a sort of authority to young officers.

When the barometer shall have risen two-tenths of an inch, then one ball will be taken off, and the other be left until the storm shall have passed over.

Hurricanes being whirlwinds, the wind in the circuit of its revolution, blows from every point of the compass within the circuit of the whirlwind. The veering of the wind is owing to the whirlwind's progress. Hence, the reason why the trade wind is often reversed during these tempests.

Ships riding at anchor in Carlisle Bay, unless their commanders prefer to remain there, cannot put to sea too early after the first indication of a hurricane.

When the wind veers from N.E. toward East with a falling barometer, it may be expected to become S.E. and S.S. East; and in this case, the centre of the storm would be passing to the southward of the island.

When the trade wind veers from North to N. by West with a falling barometer, the wind may be expected to become N.W. and West, and perhaps even S.W. and in this case the centre of the storm would be passing to the Northward of the island.

When the wind changes to North, blows steadily from that quarter, it may be expected to change suddenly to the South; in this case the centre of the storm would pass over the island.

In either case, ships remaining too long at anchor, would be in danger of becoming embayed on a Lee shore.

The hurricanes which have passed over Barbadoes, and of which we have any precise records, have all come from the Eastward. When the centre is expected to pass to the Northward of the island, ships quitting Carlisle Bay should endeavour to run to the Southward and South Eastward, by scudding in the first instance. But when the centre is expected to pass to the Southward of Barbadoes, a ship should go to the Northward, and come to the wind on the Starboard tack. By keeping to the Eastward, whilst the storm is moving Westward, the ship will sooner be out of the hurricane.

The earliest indication of a coming storm, is sometimes a heavy swell of the sea, caused by the storm at a distance.

398. Red Sky and Light. The following is from an old work, reprinted in the Nautical Magazine, Vol. for 1841, p. 666, under the title of "Eolian Researches," and I extract it entire as shewing that it is probably sometimes an atmospheric appearance, and not owing to reflections or refraction by clouds.

"Sometimes there appears first, like a flaming cloud in the horizon, from whence proceeds the fiery tempest, in a most astonishing manner, and some of these hurricanes and whirlwinds have seem'd so very terrible, as if there had

380. MODERATING OF THE WIND AT THE COMMENCEMENT OF CYCLONES. The following note from the Horn-Book of Storms for the Indian and China Seas, describes this remarkable peculiarity; of which I have again and again met with notices in numerous logs, and in many instances I have remarked that commanders have been deceived by it. The rule is simple, "*Make no sail till your Barometer rises.*"

"In the hurricanes of the Bay of Bengal and China Seas, it seems not an uncommon circumstance, that in a few hours after their commencement, there is a lull for an hour or two, or more; after which it comes on to blow harder than before from the same quarter. I observe that this is also noted in the hurricanes off the Isle of France and in the West Indies. This treacherous peculiarity might, without attention to the barometer, deceive those unaccustomed to our tempests. I have not met with an instance of these lulls occuring more than once at the commencement of a storm. I do not allude here to the lull or calm which precedes the shift of wind, which occurs when the centre of a storm is passing over a ship or place, but to a sort *of promise of fine weather* which occurs at the beginning of a *hurricane.*"

381. There is also a kind of treacherous fair weather interval when no *blowing* weather has occurred, and the only indications have been dark lowering clouds and a fall in the barometer. It is perfectly well described in the following note appended by Captain **Biden,** to the log of the ship *Princess Charlotte of Wales* in her Cyclone of March 1828 in the Southern Indian ocean. Track *k.* on Chart II.

"Previous to the gale, the weather had been unusually close, Ther. 82°, and for 48 hours the clouds were dark and fixed, with an appearance indicative of heavy rain, Barometer steady. The approaching change of the moon in its Peri-

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N. B.—On the accuracy of a log-book depends the recovery of the owner's and shipper's property in the event of loss, and the good names of the Captain and Officers. The ship's latitude and longitude should be carefully noted at every noon by observation and account, chronometers and lunars, and leeway, variation, deviation, barometer and simpiesometer duly entered. All changes of wind and weather, and peculiar appearances on the approach of bad weather should be registered. Erasures and obliterations should be avoided, and alterations certified by a note in the margin. A duplicate log should be kept and daily signed, and on the ship's return to port, all bad weather or extraordinary phœnomena should be reported.

gee caused an anxious attention to the Barometer, which gave the first warning at 11 A. M., on the 14th, falling gradually until 8 P. M., when it sunk with more rapidity then I ever witnessed, the sure presage of a storm! Without this excellent and almost infallible instrument, the most experienced seaman might have been lulled by the sudden change at 2 A. M., stars bright, clouds fixed, and every appearance of settled weather. The Barometer fell from 29.27 at midnight to 29.08, the certain precursor of a hurricane. The heavy rain had so tired and exhausted our men, that at midnight I relieved the watch in hopes of a few hours daylight to get the top-gallant masts upon deck; we had just handed the main top-sail and rounded to on the larboard tack with scarce a breath of wind, when the gale came on at W.S.W., and at 4, it blew a perfect hurricane."

382. While this page is going to Press, I see in the *Singapore Free Press*, an instance in which the brig *Guess*, with a falling Barometer at 29.50., and wind N.N.W. in the China Sea, *in the month of August* 1847, (the height of the S.W. monsoon) was seduced by an interval of moderate weather into making sail so far as to let out reefs and set top-gallant sails at 3 P. M.; having double reefed at 2 P. M. By 6 it was a strong gale, and by midnight a tyfoon (Cyclone) had commenced.

383. ETYMOLOGY (DERIVATION) OF THE WORDS HURRICANE AND TYFOON. This word Hurricane seems originally to have been a Carib or Indian one, for in the *Relacion summaria de la Historia Natural de las Indias, &c. &c.,* addressed to the Emperor Charles V. by Captain **Fernando de Oviedo,** speaking of the superstitions of the Indians (Caribs) of Tierra Firme, probably about Yucatan, the author says—

"So also when the Devil wishes to terrify them (the Indians) he promises them the *Huracan*, which means Tempest. This he raises so powerfully that it overturns houses and tears up many and very large trees; and I have seen in thick forests, and those of very large trees for the space of half a league, and continuing for a quarter of a league in length the forest quite overthrown, and all the trees, large and small, torn up by the roots; the roots of many being uppermost, and the whole so fearful to see, that it doubtless appeared to be the Devil's work, and could not be looked on without terror."*

* I give here the original old Spanish. "Asimismo, quando el Demonio los quiere espantar, prometeles el *Huracan*, que quiere decir, Tempestad: la qual hace tan grande, que derriba Casas; i arranca muchos, i mui grandes Arbo-

The author here exactly describes the passage of a tornado in a thick forest, and by the explanation he gives of the word *Huracan*, we see that it was an Indian one. The Dictionary of the Spanish Academy does not give the derivations of words. In the extract from **Ramusio** at p. 260, we find also that the same author gives the same word as the Haytian name for Cyclones.

384. TYFOON. This word is undoubtedly Chinese, and by no means derived from the Greek "Typhon," as has been supposed. Dr. **Morrison**, in his Notices concerning China and the Port of Canton, says that—

"At Hainam and the Peninsula opposite (to the North of it), they have temples dedicated to the Tyfoon, the god (goddess ?) of which they call *keu woo* "the tyfoon mother," in allusion to its producing a gale from every point of the compass, and this mother-gale with her numerous offspring or a union of gales from the four quarters of heaven makes conjointly a *taefung* or tyfoon."

In a work called "*Kw'an Tung Sin yu*" the tyfoon is called either *kow-fung* or *fung-kow*. A severe one is called *teĕ hwuy* or *Teŏ keu*, an iron whirlwind.*

They have also separate names for whirlwinds, which I am informed are called "*Yung-kok-foong*" and "*Suing-foong*."

385. These names are not questions of mere curiosity, for apart from the use to the sailor of knowing the native terms for every thing relative to his profession in every country, the mere fact of such special names existing for various kinds of gales, shews at once that there are certain well-known and recognised phœnomena, or effects, distinguishing the Cyclones. Thus in one of the South Sea Islands, they are called "the wind that breaks the bannana-trees," and I have mentioned at p. 45, the names *bagyo* and *sigua* as those given by the natives of

---

les ; i yo he visto en montes mui espesos, i de grandisimos Arboles, en espacio de media legua, i de vu quarto de legua continuado, estar todo el monte trastornado, i derribados todos los Arboles, chicos i grandes, i las raices de muchos de ellos para arriba, i tan espantoso cosa de vèr, que sin duda parecia cosa del Diablo, i no de poderse mirar sin mucho espanto."

* Captain **Doutty**, of the *Runnimede*, in his log exactly uses the same metaphor ! likening the wind ripping up the front of the poop to "a metallic body."

the Philippines to Cyclones and monsoon gales. Ships that visit the Marianas, Carolinas and other groupes, islands, and coasts of the Pacific, from the Kuriles to New Zealand and Chiloe, may collect much information by attending to the details of natives and residents relative to their different classes of storms: as for instance, we might learn from the pearl fishers and smugglers of California, and from the coast Indians, South of Valparaiso, what the usual changes of winds are in their storms, and thence deduce the tracks.

386. APPEARANCE OF THE STARS. I omitted to remark upon the only two instances, in which the appearance of the stars has been noted in our table, as indicating the approach of a Cyclone. Yet, as we shall presently see, it is probable that these bodies may often afford to the attentive observer, a warning, in corroboration at least of other signs. Capt. **Langford,** in our table, p. 227, notes only "a burr" about them, which must be common in all hazy states of the atmosphere; but Capt. **Rundle** mentions a "dancing sickly appearance" of them.* In commenting upon this in the Memoir in which his log is published, I have remarked that it may be owing to wreaths of vapour, and the intervals between them; and I have also adverted to the tremors of objects seen through telescopes in the mornings, as occasioned by the rarefaction of different strata of it, an appearance and cause usually well known to intelligent seamen. Meteorologists are also well agreed as to the usual causes of the scintillation of the stars, which I take to be the "dancing" alluded to; only that it was so excessive that it gave the idea of motion rather than mere scintillation (sparkling); but they add also, what we should in future note; that apparent changes of *colour* as well as of brightness and place occur in the stars, especially at the times when they are most scintillating; or the changes of colour may occur with the planets also, though they rarely sparkle. Thus a blue or red star may change to the opposite colours, or become remarkably silvery and white for a short time, and then return back to its usual colour. All these are matters to be noted

* Which was carefully observed; for the log, says, "I thought at first my eyes deceived me, but my mates observed the same; I suppose occasioned by some dense vapour?"

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III.	——— Southern limit,.....	Mr. Thom.
IV.	Track curving to the Southward about Mauritius, Blenheim 1807, ...	Mr. Thom and Col. Reid.
V.	About Mauritius and Bourbon, ...	Mr. Thom.
VI.	Curve of the Culloden's Hurricane, March 1809, ...	Col. Reid.
VII.	H. M. S. Serpent, Feb. 1846, ...	H. Piddington.
VIII.	Futtle Rozack and other Ships, Nov. 1843, ...	H. P. in 11th Memoir, Jour. As. Soc.
IX.	Charles Heddle's Storm, March 1845,	H. P. 13th Memoir J. A. S.
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XI.	H. M. S. Albion, Nov. 1808, ...	Mr. Thom.
XII.	H. C. S. Bridgewater, March 1830, ...	Col. Reid and Mr. Thom.
XIII.	H. C. S. Abercromby, Jan. 1812, ...	Mr. Thom.
XIV.	Maguasha, Feb. 1843, ...	Mr. Thom.
XV.	H. C. S. Ceres, —— 1839, ...	Mr. Thom.
XVI.	Timor and Rottee Storm, April 1843,...	Mr. Thom.
XVII.	Malabar, Jan. 1840, ...	Mr. Thom.
XVIII.	Boyne, Jan. 1835, ...	Col. Reid.
a.	Mauritius, March 1811, ...	Col. Reid.
b.	———, Feb. 1818, ...	Mr. Thom.
c.	———, Jan. 1819, ...	Mr. Thom.
d.	H. C. S. Dunira, Jan. 1825, ...	H. Piddington.*
e.	H. C. S. Princess Charlotte of Wales, Feb. 1826, ...	H. P.
f.	H. C. S. Orwell, Feb. 1827.	H. P.
g.	Thalia, April 1827, ...	H. P.
h.	H. M. S. Boadicea, April 1827, ...	H. P.
i.	H. C. S. Macqueen, Jan. 1827, ...	H. P.
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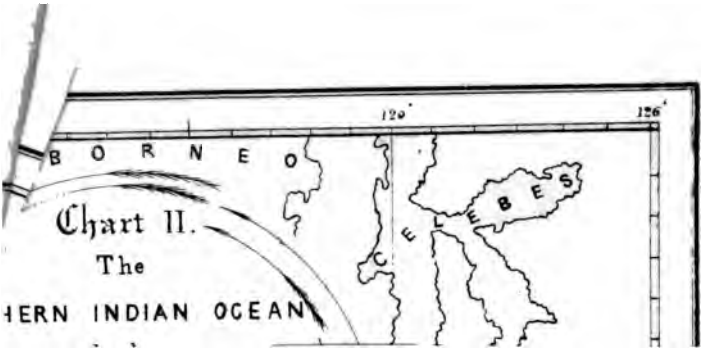
k.	——— Princess Charlotte of Wales, March 1828, ...	H. P.
	Jan. 1831, ...	H. P.
		Mr. Reid


120°
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B O R N E O
Chart II.
The
HERN INDIAN OCEAN
C E L E B E S

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II.	Coringa, Preparis, and Megna River Hurricanes,	November,	1839.
III.	Cuttack,	April and May,	1840.
V.	Madras,	May,	1841.
VII.	Calcutta,	June,	1842.
VIII.	Madras and Arabian Sea,	Oct. and Nov.	1842.
IX.	Pooree, Cuttack and Gya Storms,	October,	1842.
X.	Madras and Masulipatam,	May,	1843.
XI.	Bay of Bengal,	Nov. and Dec.	1842.
XII.	*Briton* and *Runnimede's* Hurricane,	November,	1845.
XIV.	Bay of Bengal, Ceylon and Arabian Sea Hurricane,	Nov. and Dec.	1845.
a	Ongole Hurricane,	October,	1800.
b	H. M. S. *Centurion*,	December,	1803.
c	„ *Sheerness*,	January,	1805.
d	Frigate *Dover*,	May,	1811.
e	Kistnapatam, *Palmers*,	March,	1820.
f	Burrisal and Backergunge,	June,	1822.
g	*Liverpool* and *Oracabessa*,	May,	1823.
h	Balasore and Cuttack,	October,	1831.
i	*London*,	October,	1832.
j	*Duke of York*,	May,	1833.
k	Calcutta,	August,	1835.
l	Madras,	October,	1836.
m	*Protector*,	October,	1838.
n	Kyook Phyoo,	May,	1834.
o	Kyook Phyoo, *Syren* and *Java's*,	November,	1838.

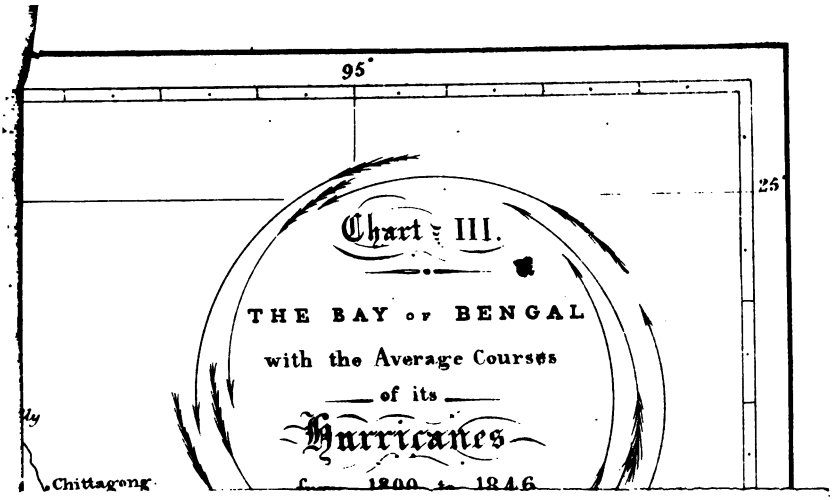
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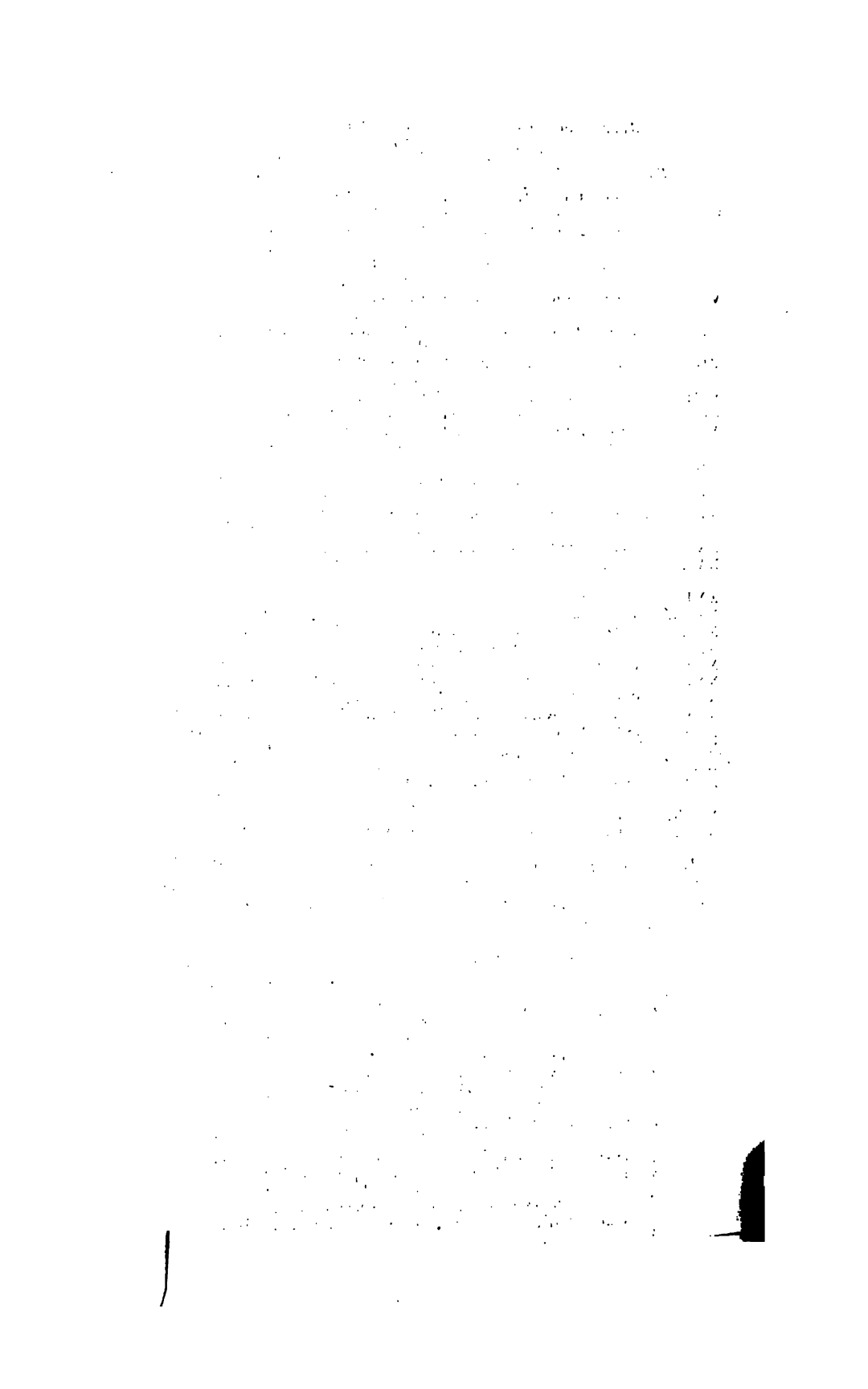
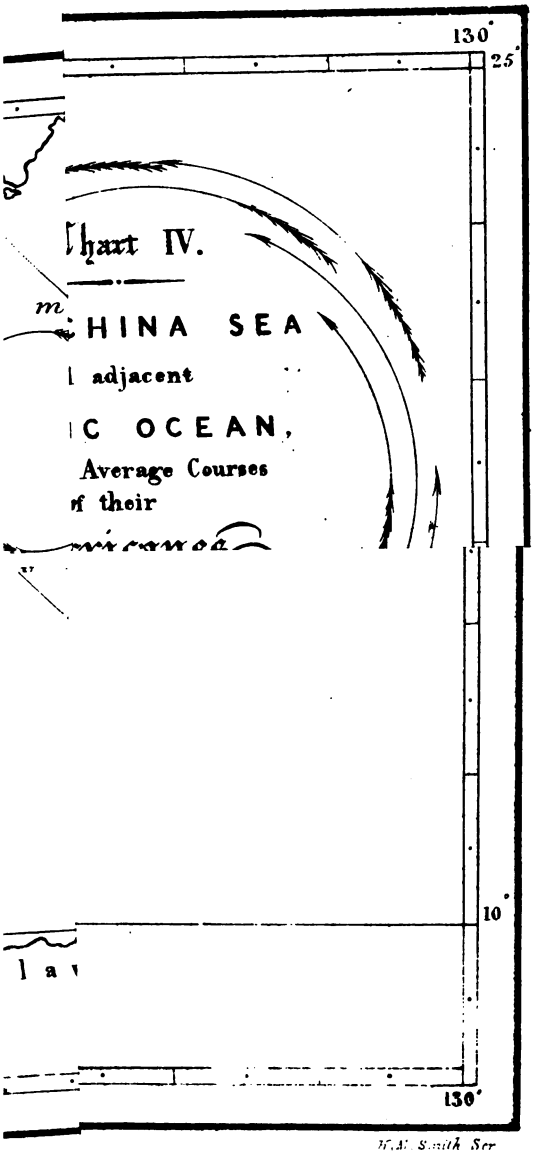
Chart III.
THE BAY OF BENGAL
with the Average Courses
of its
Hurricanes
from 1800 to 1846
Chittagong



References to Chart No. IV.—The China Sea and Adjacent Pacific Ocean.

No. of Track.		*Dates.*	*Names.*	*Authority.*
I.	1780.	17th July, ...	H. C. S. London,.....	H. Piddington.
II.	1797.	19th June, ...	H. C. S. Buccleugh,.....	H. P.*
III.	1803.	20th to 23d Sept....	H. C. S. Coutts, Camden, &c.,.....	H. P.
IV.	1803.	20th September,..	H. C. S. Royal George, Warley, &c.,.....	H. P.
V.	1809.	28th & 29th Sept.,	H. C. S. True Briton and Fleet,.....	H. P.
VI.	1810.	29th & 30th Sept.,	H. C. S. Elphinstone and Fleet,.....	H. P.
VII.	1812.	8th & 9th Sept.,..	H. M. S. Theban and Fleet,.....	H. P.
VIII.	1819.	28th & 29th Oct.,..	H. C. S. Minerva,.....	H. P.
IX.	1820.	29th November,...	H. C. S. Ld. Castlereagh,	H. P.
X.	1821.	18th & 19th Oct.,..	H. C. S. General Kyd and General Harris,..	H. P.
XI.	1822.	14th & 15th Sept.,.	H. C. S. Macqueen,.....	H. P.
XII.	1826.	25th to 27th Sept.,.	H. C. S. Castle Huntley,	H. P.
XIII.	1829.	9th August,.....	H. C. S. Bridgewater,..	H. P.
XIV.	1829.	8th & 9th August,	H. C. S. Chas. Grant, Lady Melville, &c.,...	H. P.
XV.	1831.	23d September,....	At Canton, ...	H. P.
XVI.	1831.	23d October,.....	At Manilla and the Panama's first Storm,....	Mr. Redfield.
XVII.	1831.	24th & 25th Oct.,....	Panama's second Storm,	Mr. Redfield.
XVIII.	1831.	25th & 26th Oct.,...	Fort William,.....	H. Piddington.
XIX.	1832.	3d August,.....	At Canton and Macao,	H. P.
XX.	1832.	22d to 25th Oct.,...	Moffatt,.....	H. P.
XXI.	1833.	28th August,.....	Brigs Virginia and Bee,	H. P.
XXII.	1833.	12th October, ...	H. C. S. Lowther Castle,	H. P.
XXIII.	1835.	3d July,.....	Barque Troughton,....	H. P.
XXIV.	1835.	4th August,.....	H. M. S. Raleigh,.....	Mr. Redfield.
XXV.	1837.	16th to 22d Nov.,....	Ariel and Vansittart,...	H. Piddington.
XXVI. XXVII.	1889.	22d to 24th Sept.,...	Cal. Thetis, London Thetis, & Golconda,	H. P.
XXVIII.	1840.	29th & 30th Nov.,...	French Frigate Magicienne and St. Paul,...	H. P.
XXIX.	1841.	21st July,.....	Hong Kong Fleet,.....	H. P.
XXX.	1841.	26th July,.....	Hong Kong Fleet,.....	H. P.

The foregoing are tracks from the Chart to my Sixth Memoir, "The Storms of the China Sea." (Journal As. Soc. Vol. XI.) The following are mostly from materials since collected, but of which the details are not yet published.


130°
25°
Chart IV.
CHINA SEA
adjacent
C OCEAN,
Average Courses
of their
10°
130°